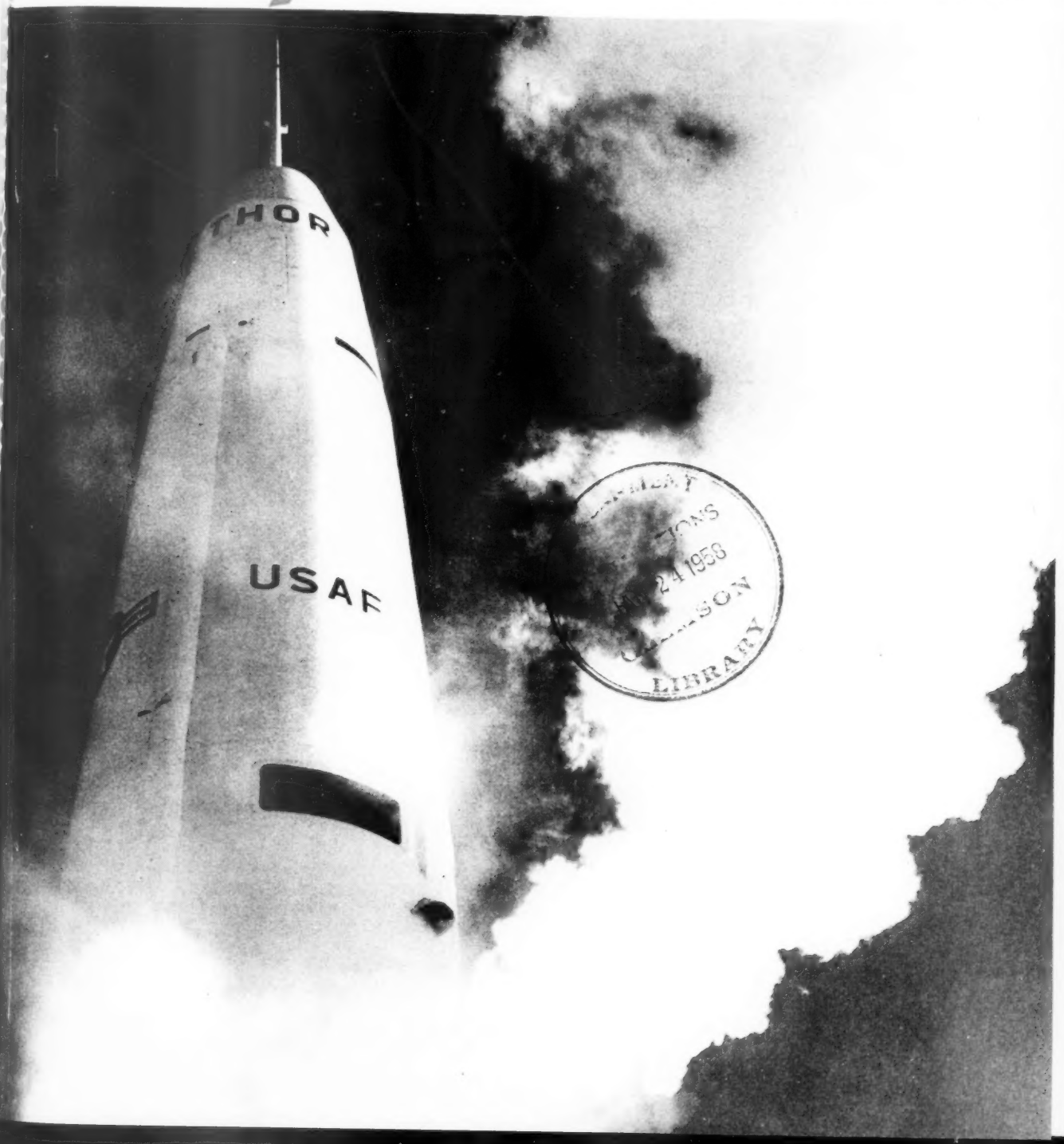
DECEMBER 1957

the Airman

OFFICIAL JOURNAL OF THE AIR FORCE



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Wherever there are two, they are not without God; and wherever there is one alone, I say I am with him. Raise the stone, and there thou shalt find me; cleave the wood, and there am I.

FIFTH LOGION

the Airman

OFFICIAL JOURNAL OF THE AIR FORCE

VOLUME 1, NUMBER 5 DECEMBER 1957

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MISSILES, PILOTS, AND SPACE

The Air Force policy on missile development and employment is:

★ The United States Air Force has long recognized the potential of missiles. According to current roles and missions the Air Force has the greatest operational need for such weapons.

★ Missiles and aircraft can be combined, capitalizing on the performance and characteristics of each, to create a formidable instrument of airpower considerably greater than the use of missiles or aircraft alone. The creation of such an instrument is a primary objective of the Air Force.

★ Missiles, as they are perfected, will supplement and complement the manned aircraft. However, to preserve the required capability and flexibility of operations, it is essential that the Air Force maintain a significant force of manned aircraft during the foreseeable future.

★ The Air Force has and is continuing to develop missiles for use in the strategic, tactical, and air defense roles as fast as technology and availability of funds will permit.

★ As rapidly as missiles become operationally suitable, they will be phased into units either to completely or partially substitute for manned aircraft according to military requirements.

In this issue are articles that are directly related to this policy. On p. 5, Col. Edward N. Hall, Air Force Ballistic Missile Div., Hq ARDC, in *Air Force Missile Experience* discusses our work and interest in missiles over years. He points out some of the significant contributions made by the Air Force in missile development.

Brig. Gen. Charles M. McCorkle, Assistant Chief of Staff for Guided Missiles, Hq USAF, in *Command and Control of Ballistic Missiles*, p. 10, discusses some of the problems involved in these new weapons and raises some thought-provoking questions. He states, "By no means do I have all the answers. My primary purpose is to stimulate thinking on the subject." The article is timely since the 1st Missile Division has been transferred to SAC and the *Thor* placed in production. The above two articles are reprinted by courtesy of the *Air University Quarterly Review*.

The Rascal, p. 15, tells how the missile has been combined with the manned aircraft to utilize the capabilities of both.

Training the Pilots of Tomorrow, p. 26, takes you to FlyTAF for a look at the training necessary to win wings. The missile has not eliminated the pilot because ". . . it is essential that the Air Force maintain a significant force of manned aircraft during the foreseeable future."

On November 29, General White told the National Press Club in Washington, "We airmen who have fought to assure that the United States has the capability to control the air are determined that the United States must win the capability to control space. In speaking of the control of space, I want to stress that there is no division, per se, between air and space. Air and space are an indivisible field of operations." On the back cover is a graphic chart, courtesy of Convair, on Astronautic Systems. Astronautics has been defined by Hubertus Strughold, Chief, Dept. of Space Medicine, USAF School of Aviation Medicine, as ". . . the science or art of the design, production, and operation of a space craft." This chart presents some ideas along this line.

USAF PERIODICAL 30-15

SUBSCRIPTIONS

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THE AIRMAN is primarily a medium for the exchange of ideas and information among Air Force personnel. Readers are encouraged to submit articles, short subjects, photographs and artwork. All contributions will be given consideration; suggestions and criticisms are welcomed. Opinions expressed by individual contributors do not necessarily reflect the official viewpoint of the Department of the Air Force. All photographs are official USAF photos unless otherwise designated.

Use of funds for printing this publication approved by the Secretary of the Air Force and the Director of the Bureau of the Budget July 5, 1956.

FROZEN FIELDS

Sir: *I have read* THE AIRMAN *with interest and would like to take this opportunity to recommend a solution to a situation which, in my opinion, is growing more acute day by day—the frozen career field.*

Let me cite my own particular case. I am a 62350 (meat cutter). I have 16-years service; nine in grade. I haven't been able to get a 70; my career field, as well as many others, has been frozen in the upper NCO level for around five years. In that time many basic airmen in other fields have come up to and passed us in rank. When we enlisted, the majority of us had little or no voice in selection of career fields. We took what was handed out.

At present there is no opportunity for me to cross-train as airmen overseas are not eligible during that tour of duty and must wait to apply for cross-training upon return to the States. Even then, while cross-training may be the answer for some, those, like myself, who have only a short time remaining before retirement, would not gain anything.

I would like to offer the following suggestion as a possible solution in this matter. I consider it a small measure of compensation, but to me it would make the future a little more hopeful; it would at least give me something to look forward to.

My plan is this: Automatically promote to the next highest rank at time of retirement any airman that had required time in grade for promotion at time of freeze, and who has been in frozen career field three years or longer. The boost in morale this would induce would more than compensate the added expense to the Government.

S/Sgt. Francis Brownley
APO 235, San Francisco, Calif.

This letter, reprinted in considerably shortened form, was referred to officials in the Career Development Division, Hq USAF. The answer printed here is based upon information supplied THE AIRMAN by that division.

The surplus situation itself is extremely complicated, but the Air Force is doing all in its power to alleviate the problem. Basically it came about through manning of these fields during periods of build-up such as World War II and the Korean conflict. Attrition within these fields has proven to be less than in others. At the same time, new personnel had to be trained to fill slots at lower ranks opened through promotion of men already in the fields. No organization can operate with all chiefs and no Indians. Surpluses do not develop because of overpromotion, but rather because of a steady decline in requirements. Therefore, with the cutback to normal peace time personnel levels, surpluses were created in certain fields.

Promotions must be made in accordance with requirements. The Air Force receives funds for its personnel program based on its ability to prove it has a requirement for a specified number of airmen in each grade skill. If these funds are not used for promotion in these skills, the appropriations cannot be justified.

Therefore, the only logical course of action left to the USAF is elimination of its surplus airmen by attrition and cross-training. This is being done. However, even with this method, selectivity must be the keynote. Cross-training of airmen with little time remaining before retirement is of questionable value, both to the airman and to the Air Force. But it is hoped that sufficient cross-training of airmen with assured periods of service can be accomplished in order to restore promotion opportunities at an early date in skills which are now surplus. Meat cutting (623) is one of the skills from which technical sergeants are being encouraged to cross-train, providing they have the aptitudes in other fields and have more than four years' service remaining.

Concerning the recommendation for promotion of one grade upon retirement of men within frozen fields, the Air Force cannot subscribe to such a plan. This practice would be contrary to the intent of retirement legislation and could very possibly result in changes in this legislation.

★ ★ ★

SCHOOL OF HARD KNOCKS

Sir: *I had finished 93 credit hours of college work before I entered the Air Force.*

I am presently assigned to Shaw AFB, and would like to continue my studies at the University of South Carolina in Columbia, approximately 50 miles from the base. Shaw does not furnish transportation for such purposes, the local bus does not return to the base after classes are out in the evening, and I have no personal automobile which makes the transportation problem very difficult.

I have read in USAF papers that Mitchel AFB, N. Y. has set up a full time college program for personnel in the Armed Forces. My base educational officer told me the program was for airmen at Mitchel AFB only.

Since I am so close to graduating, I'm wondering if I can be transferred up there to finish up so I can go on "Operation Bootstrap."

A/2C Donald J. Lombardi
Shaw AFB, S. C.

The Warrant Officer and Airman Assignment Division, Military Personnel, Hq USAF advises provisions do not exist for reassignment to enable an individual to attend off-duty classes. In addition, there are no plans to institute such a program.

★ ★ ★

FLAME OUT

Sir: *The October issue of* THE AIRMAN *was very informative and quite interesting. The Article* "TAC is Global" *did have a very noticeable flaw in it though.*

The flaw I'm speaking of is in the paragraph, "Pots of shrimp creole rattle on the stoves in Louisiana when a squadron of Republic F-84F Thunderstreak fighter-bombers kick in afterburners over England AFB."

Show me a squadron of F-84Fs with afterburners and I'll withdraw this letter. We've been flying this aircraft at this base for over three years and they just don't have afterburners.

S/Sgt. John W. Hoffman
Bergstrom AFB, Tex.

The author's only comment was, "If they tell me now that they no longer make shrimp creole in Louisiana, my disillusion will be complete." For reader Hoffman, no argument—no afterburner.

★ ★ ★

SOCIAL SECURITY

Sir: *Where can I write or who can I contact to find out how many credits or quarters I have earned under the Social Security system since 1938. I have been in the Air Force since 1943.*

S/Sgt. Russell L. Lawson
APO 929, San Francisco, Calif.

For Sergeant Lawson and other readers who desire similar information, the Department of Health, Education, and Welfare advises inquiries should be directed to Social Security Administration, Candler Building, Baltimore, Maryland. Requests should include Social Security number and date of birth.

Artist's conception of Air Force Missile Programs reproduced from *Kaiser Aluminum News* published by Kaiser Aluminum & Chemical Corp.

Air Force Missile Experience

by Col. Edward N. Hall

It is probable that more misinformation has been generated on the subjects of guided missiles, long-range missiles, ballistic missiles, intermediate-range missiles, and intercontinental missiles than on almost any other conceivable subject. What are these devices, how do they differ from each other, why have they come into being, what has been their past history? The answers available to the general public have been fragmentary and frequently misleading, primarily because of their inevitable security restrictions. This has been a highly justifiable policy in the past, but at this time the American public and its high-ranking civil administrators are being confronted with crucial decisions concerning these weapons, their control, and their use and are possibly being forced to conclusions based upon a paltry smattering of factual background. This article is being written in an effort to dispel some of the mists of obfuscation that pervade this field.

Missiles may be divided into two categories: ballistic and airfoil controlled. Both categories have been somewhat arbitrarily further divided into guided and unguided species. The word arbitrary is employed here because it is hard to conceive of any justification today for a truly unguided missile, one deliberately designed to take off and capriciously land, "I know not where." Guided missiles follow trajectories that may be altered by signals from some guidance device well after the moment of launch; unguided missiles are those in which all guidance influence ceases within an extremely short time after launch.

Both ballistic and airfoil-controlled vehicles have been employed by mankind for a very long time. Ballistic weapons as rocks hand cast by primitive man preceded their airfoil-controlled cousins, arrows launched from bows and controlled by tail feathers, by a significant period of time. A greater amount of effort through the years has gone into the ballistic-controlled vehicles than into the airfoil-controlled ones (e.g., rocks thrown by hand or catapult and gun-propelled slugs and shells). Only recently has serious consideration been given to the development of relatively long-range airfoil-controlled weapons. An essential ingredient in the development of relatively long-range ballistic devices was the creation of a basic science of ballistics. Similarly a sizable mass of data in the field of aerodynamics was a necessary precursor to the development of long-range airfoil-controlled vehicles.

Ballistic science is much the older of the two, stemming back pretty directly to Kepler's Laws of Motion, which have been constantly and repeatedly confirmed by such phenomena of celestial mechanics as the motions of the moon, planets, and comets. Aerodynamics could not support accelerated development of long-range devices until late in the 19th century. Exercising these two general sciences man has developed a series of missiles.

In the course of this activity, cross-pollinization in the two fields has occurred to such an extent that the course of individual developments has in many cases become obscure. For many years ballistic missiles, considered apart from their launching devices, were simple. The shell hurled from a big gun, although differing in degree of sophistication, had much in common with the rock launched from the hand of primitive man. Aerodynamic effects in both cases were small. The trajectories resulted largely from the interplay of gravity, conservation of momentum, and, in the case of extreme ranges, centrifugal force. Extremely strong lightweight structures were not needed.

Significantly the method of propulsion employed in the gun involved the use of very heavy launching devices of a relatively declining effectiveness as muzzle velocities in excess of about 4,000 feet per second were reached. Projectiles were guided by accurately aligning the gun in the direction and elevation desired. No guidance signals were transmitted to the projectile after exit from the gun barrel. While sta-

bility was imparted by projectile spin, even at this relatively early level of missile sophistication a certain degree of hybridization occurred; fin-stabilized gun-launched projectiles were developed, in which a certain amount of aerodynamic science was drawn upon. The serious development of long-range, aerodynamic-controlled missiles had to await the development of the airplane.

Quite early in this saga attempts were made to apply this newer science to long-range missiles. Even during World War I efforts were made to load military airplanes with bombs and direct them without pilots to specified targets. Out of aerodynamic science grew automatic control devices such as autopilots, auto navigation equipment of both radio and inertial varieties, automatic bombing systems, and the advent of reliable, efficient propulsion systems. It became evident that a proper integration of these sophistications could make practical an unmanned, long-range, aerodynamically-controlled missile. During World War II several instances of the operation of such devices took place.

Up to this point a fairly distinct demarcation existed between ballistic and aerodynamic approaches. Ballistic vehicles were dense, unsophisticated structures, most of them propelled by expanding gases generated by combustion of solid propellants in gun barrels. No provisions were made for internal control, guidance, or propulsion equipment. Aerodynamic missiles, on the other hand, sprang directly from airplane experience. In these were automatic control systems, strong, lightweight airframes, sophisticated guidance systems, and advanced propulsion units.

Modern Missile Beginnings

Until the war the potential performance of long-range missiles was largely misunderstood. The barrier to be overcome was not of sound, or heat, but of the mind, which is really the only type that man is ever confronted with anyway. A traditional approach by the aerodynamic people to the problem of range versus speed had convinced them that an inverse relationship existed between these two parameters and that, consequently, truly long-range, airfoil-controlled vehicles would have to travel at relatively slow speeds. The ballistic advocates, also limited by mental blocks, thought in terms of thousands of yards rather than thousands of miles. Although the latter group had had rockets at its disposal for hundreds of years, it had employed them in a manner highly analogous to the gun. Thus aerodynamicists talked about relatively slow devices capable of ranges up to 10,000 miles or so, employing reciprocating or compound engines with conventional propellers and high-aspect-ratio airfoils. Military ballistic people were thinking in terms of rocket- and gun-propelled projectiles with unsophisticated structures and very limited guidance and control systems capable of ranges of hundreds of thousands of yards.

Between these two placid pools of specialized interest there were several small, disturbing anomalies. Dr. Robert Goddard in the United States and the Weapon Development Group of the German Army were pursuing programs of high-performance rocket development. Dr. Goddard was completely unsuccessful in his efforts to interest the United States armed forces in his work, and the German effort, until a time too late to be of any influence in deciding the outcome of World War II, was similarly ignored. The efforts of both of these groups were aimed at the development of a desirable hybrid in which the sophistication of the aerodynamic approach would be effectively applied to a ballistic vehicle. These efforts incorporated the subtle structural talents of the airframe industry and the highly sophisticated guidance and control mechanisms developed for imparting stability to, navigating, and controlling bomb release from modern airplanes—all this married to a high-performance rocket propulsion system to produce an entirely new species of vehicle.

Except for the propulsion system all elements stemmed directly from the airplane development art. And the rocket propulsion systems employed on these devices, in the United States at any rate, have also stemmed from the propulsion development programs of the United States Air Force. The problems of heat transfer, turbine operation, combustion, and pumping are intrinsically the same as those that plagued the developers of reciprocating engines, turbojet engines, ramjet engines, and other aeronautical power plants. These rocket engines have been developed by the same U.S. Air Force and affiliated organizations that developed the preceding types of power plants mentioned, using the same basic philosophies. The result is that large liquid-rocket power plants are available today as reasonably reliable, producible items to provide the extreme propulsion requirements of the long-range guided ballistic missiles. The rapid advance of the Air Force ballistic missile program has been predicated upon this rich background of familiarity with, and development of, all the key elements required for success in its field.

The Rate of Development Progress

The rate of progress achieved in ballistic missile development has been limited by two categories of factors: the operational and the technical. That ballistic missile development can only be carried out by the armed services is an accepted fact. Armed services, however, must always seek to justify their development activities in terms of the economic validity of the gains to be achieved. No new weapon, however spectacular, can really be justified unless it promises to perform military tasks at a lower gross cost than will any weapon system preceding it. A rocket-propelled, guided ballistic missile of short range would be questionable from an economic standpoint if compared to the operating cost of the manned bomber. Even a relatively long-range missile of this variety would be questionable until the detonation magnitude of its warhead and the accuracy with which it could be positioned made it less costly per unit of effectiveness than the piloted bomber. Questions would still arise about the methods of reconnaissance and bomb-damage assessment that could be employed as a necessary adjunct to such a weapon system.

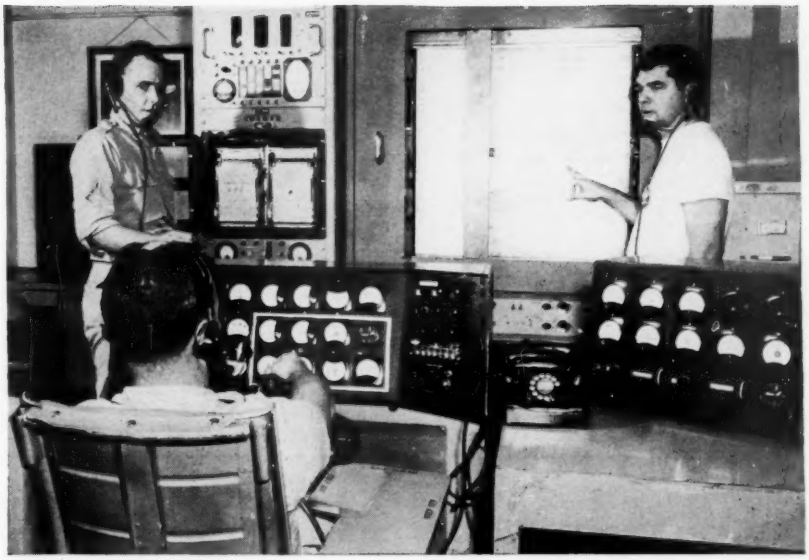
A limiting factor in the missile development drive until very recently was the questionable effectiveness

of available warheads and guidance systems. Obviously the use of a TNT warhead on a ballistic missile with a range of more than a thousand miles would be extremely costly. With missiles dispersing several miles in the target areas, as they must with today's guidance systems, several thousand would be needed to destroy a specific target of limited size. As the accuracy of the guidance system improves and as the detonation effectiveness of the warhead increases, the numbers of missiles required to perform any specific military task drop—as do comparative costs.

The atomic bomb greatly improved the destructive potential of this type of missile, but even it, when coupled with available guidance accuracies, did not guarantee economies beyond the use of manned bombers. With the atomic warhead such economies could only be achieved by the development of extremely accurate guidance systems. It was the thermonuclear bomb that altered this picture radically. This weapon promised economical dividends in the destruction of military targets by means of long-range ballistic missiles. So it is that from the operational point of view the drive to develop these missiles was compromised by lack of clear-cut evidence that their employment was militarily justified until improvements in warhead and guidance techniques occurred.

A much more basic limitation to the development of long-range ballistic missiles existed up to 1950—adequate propulsion systems. The long-range ballistic missile consists of guidance, control, structure, warhead, and propulsion. Each of these must be adequate if there is to be a worthwhile military missile. The propulsion system is in a somewhat different category from the others. This is the one component without which the missile could not fly at all. In fact the long-range ballistic missiles are so intimately tied up with rocket propulsion systems that frequently the terms missile and rocket are used interchangeably.

A fallacious concept, formerly widely cherished by airpower "experts," that the relationship between range and speed was an inverse one has already been mentioned. There



The SM-62 *Snark* "pilot" at his console in the foreground, flies the "bird" during a routine test over the range.

was evidence upon which to base this false conclusion in the form of ranges and speeds of the aircraft developed prior to the 1950s. Some of this evidence centered on the assumption that lift for these long-range vehicles would inevitably be supplied aerodynamically.

As soon as one accepts the fact that centrifugal force is quite as reliable as aerodynamic lift—attested to by the degree of assurance man has developed that the moon will not fall down—the picture becomes greatly clarified. While the attainment of Mach 1 speeds was always accompanied by very limited ranges in that era, this limitation was largely a product of the characteristics of air-breathing engines, available conventional fuels, and aerodynamic drag. It was always evident that if one could get out of the atmosphere and reach orbiting velocities, terrestrial range would become unlimited. The problem lay in the development of a power plant and structural system capable of attaining orbiting speeds outside the earth's atmosphere. What structures and what power plants can be used?

A survey of existing power-plant and structural concepts reveals that the choice is a narrow one. The reciprocating engine and propeller combination is only effective at relatively low altitudes and speeds. Propeller efficiencies drop very rapidly at great altitudes unless the blades are extremely large and heavy. The ratio of thrust to drag attainable with this type of propulsion system is very unfavorable for high-speed flight. Turbojet and ramjet engines suffer the same general deficiencies, although the turbojet engine is greatly superior to its reciprocating brother in thrust-frontal area and thrust-weight ratios. But the value of the compressor element of the turbojet approaches zero as forward speeds rise above Mach 3. This is so because the inevitable rise in stagnation temperature brought about by the forward speed of the aircraft, when coupled with the further temperature rise through the turbojet compressor, heats the incoming air to the no-thrust point in this speed range. This limitation is imposed by structural problems stemming from limitations in the strengths of available materials at high temperatures. Advanced cooling techniques and further development of high-strength, high-temperature-resistant materials may push this limit up but not to any useful degree when compared with the speed requirements necessary for orbiting the earth. The case for the ramjet, similar to that of the turbo-

jet, is slightly more favorable. Here we do not have to worry about structural loads on centrifugally stressed turbine and compressor elements. The high stagnation temperature of the incoming atmosphere remains as a severe problem. The twin necessities of furnishing a reasonable static pressure to support combustion and a very high forward speed to sustain flight cause stagnation temperatures in the combustion chambers and discharge nozzles to become limiting at about Mach 5. This is still very far from earth-orbiting velocity.

Only in the non-air-breathing rocket engine does none of these intrinsic limitations bar the way to earth-orbiting velocity. Since the rocket uses no air, high stagnation temperature of surrounding atmosphere is of no consequence to the power plant. Developing thrust more effectively in vacuum than in the atmosphere, rocket-propelled vehicles may approach and exceed orbiting velocities without the problems associated with atmospheric friction. Theoretically, therefore, the rocket power plant should be capable of attaining earth-orbiting speeds and unlimited terrestrial flight ranges at very high velocities. Development of rockets of sufficient specific impulse, structural lightness, and reliability for long-range ballistic application had to await the development of modern metallurgical techniques of propellent chemistry, and of the thermodynamics required to determine what performance was available from the materials at hand.

Rocket Engine Development Program

At the conclusion of World War II the Air Materiel Command of the Army Air Forces became interested in the further development of the German A-4 type rocket. As a result the rather battered components of three of these engines were shipped from Germany to North American Aviation, the contractor designated by the project office at Air Materiel Command. At this time no large-scale liquid-rocket development facilities existed in the United States. Two large test stands and associated equipment for the development testing of these engines were to be erected at Edwards Air Force Base. Shortly after this, agreements were reached between the Air Materiel Command and the Curtiss-Wright Corporation for the use of Dr. Robert Goddard's patents in the Army Air Forces' rocket development work. Additional work to establish the operational effectiveness of nitric acid as a rocket oxidant was contracted at Aerojet, Bell, and Kellogg.

The Hughes *Falcon* guided aircraft rocket's power plant provides supersonic speed as its own guidance system directs it to a maneuvering target.

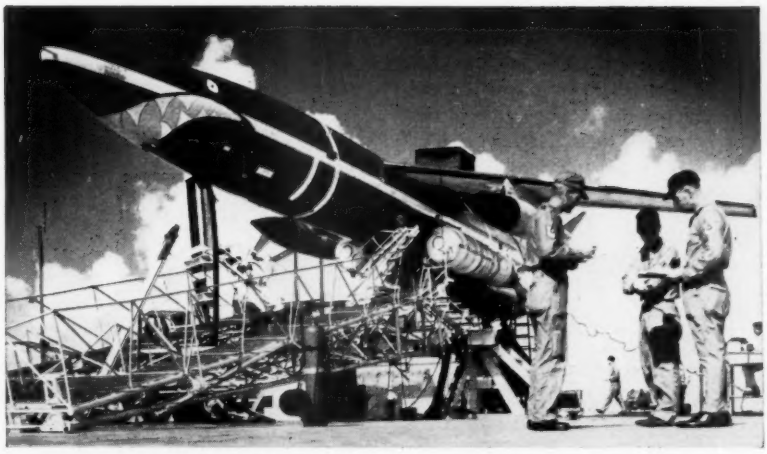
It was the conviction at this time of the Army Air Forces, which became the United States Air Force in 1947, that the rocket development program should be handled in a manner like that of other engine development programs. Traditionally industry had always been regarded as a partner in these ventures. It was felt that a continuation of this policy would make available the most competent organizations and best brains for rapid exploitation of rocket art. The former Air Corps' engine development programs, dating back to the days of the Hispano-Suiza and Liberty engines of World War I, had attempted to harness available sources of industry to development and production programs. The Air Force feels today that this was a wise decision. The fact that the only successful large liquid-rocket engine programs in the United States have been Air Force programs is in no small measure due to this manner of operation. This policy has greatly eased transition from applied research to development to production and has minimized scientific stagnation.

Since the inception of these rocket development programs the Air Force has spent large sums of money on the development of rocket engines. This expenditure was justified by the belief that only through the development of such power plants could high-speed, long-range guided ballistic and aerodynamic missiles be created. The men entrusted with the development of this device for the U.S. Air Force were experienced in developing successful reciprocating and turbojet engines. They had no delusions about the relationship between demonstration of basic principles and completed development of rocket engines adequate in reliability and simplicity for inclusion in the military inventory. The Air Force understood that preliminary design and demonstration of feasibility of basic principles amounted to less than five percent of the costs of an engine-development program. Each rocket-development project, in the Air Force view, would be faced with a long period of component tests, engine shakedown, and redesign. This realistic attitude has meant that the activities have seemed unspectacular, and achievements have seemed to be at-

tained at a relatively slow pace.

By 1949 the first large engines based on the recovered V-2 fragments had been fired at the new rocket facilities of North American Aviation. They developed thrusts and thrust-weight ratios considerably in excess of the German units. But the Air Force and its contractors, with a now respectable background of rocketry, realized that the basic German approach to the power plant was rather limited. During 1950 it was decided that this initial engine effort would no longer meet more ambitious Air Force requirements, and the entire program for large liquid-rocket engines was reoriented toward larger, lighter, higher-performance units. This enlarged program produced rocket engines useful not only to the Air Force but to the Army as well. When the U.S. Army Ordnance Corps, sponsoring the Redstone Missile Development Program, had no adequate engine available within its own facilities, the Air Force made its engine available to Army Ordnance. It has since been successfully employed as the power plant for the Redstone missile.

During this same period, vigorous programs to develop a family of nitric-acid-hydrocarbon rockets were being sponsored by the Air Force at various contractor plants. One of these development programs, intended for airplane application, involved subscale unit firings to establish the basic characteristics of this propellent pair. This subscale unit went through many metamorphoses of development and finally provided the basic device around which the current *Nike* engine is built.



The Air Force *Snark* (SM-62), an intercontinental pilotless aircraft developed by Northrop, is poised at Cape Canaveral, Fla., as 6555th Guided Missiles Squadron personnel perform final check to insure successful flight.

Development Philosophy

Although the bulk of Air Force development work is left to industrial contractors, the role played by Air Force engineers should not be overlooked. Air Force development procedures have been designed to receive the most from industry for the taxpayers' dollar—to develop power plants that are practical ventures yet press the current limits of the state of the art. A key element in this development is availability of Air Force officers of sufficient technical competence to recognize real potentials of scientific development, to discard pseudoscientific hogwash, and to apply, through good management techniques, lessons learned on previous engine programs. There is no way in which the responsibility for setting up weapon-development programs can be divorced from the military. If the objectives of such a development program are unreal, the contractor regardless of his intrinsic competence, will fail. If proper guidance is not supplied by the military, the contractor's program will be so prolonged as to invite exceedingly high costs and produce very little of technical merit.

Because the Air Force was convinced that long-range rocket-propelled missiles would become necessary weapons and that the development of suitable rocket engines would be the pacing factor for these missiles, its rocket programs continued even through the years of lean appropriations prior to the Korean conflict. As a result when the ballistic missile designers' job was suddenly and dramatically eased by the advent of practical, lightweight thermonuclear warheads, the Air Force was ready to begin matching this development with a ballistic missile delivery vehicle. Rocket-propellent pairs had been selected as best for this job because of economy, availability, performance, and handling characteristics; engine components were in a realistically advanced state of development, and the means of estimating facility, manpower, and dollar requirements to meet accelerated programs had been developed. On the firm foundation of this continuous, vigorously prosecuted Air Force rocket development program, all the long-range and intermediate-range ballistic missiles now in development by the United States have been based. Again at this stage of the development of rocket engines, the Air Force has made available its rocket engines to the Army Ordnance Corps for use in the *Jupiter* program.

Structure and Control

All the components of long-range ballistic and aerodynamic missiles, except for the rocket-engine power plants, are direct descendants of basic components in modern military aircraft. The Air Force and its contractors spent 25 years developing structural materials and manufacturing techniques that offer high strength and low weight. A high percentage of the cost of the development of lightweight alloys and high-temperature alloys in this country has been underwritten by the U.S. Air Force in one form or another.

In ballistic missiles, range is an especially sensitive function of the ratio of propellent weight to total weight. Two items essential to long ballistic ranges are high-performance rocket power plants and extremely low weights of structural

elements. In recognition of this, shortly after World War II the Army Air Forces started a program with Convair for intensive studies of structure, control, and guidance of long-range ballistic missiles. This program eventually led to impressive advances in control of ballistic missiles through gimbaling of rocket engines, better understanding of the requirements of guidance components, and a lightweight structural concept now employed in the Air Force ICBM program. The basic structures of all the long-range and intermediate-range guided missiles, ballistic and aerodynamic, of the USAF are highly sophisticated and employ subtle techniques coupled with carefully chosen materials to attain strength-weight ratios of a very high order. Each of the Air Force missiles has developed a structure peculiarly suited to the specific purpose. That these structural approaches have produced superior results is indicated by the recent action of the Army Ordnance Corps. After it examined the basic structure of the Air Force *Thor* missile, Army Ordnance decided to alter its basic structural design of the *Jupiter* missile to permit employment of the materials and fabrication techniques utilized on *Thor*.

The extension of missile control systems beyond performance limits of piloted aircraft has not proved as difficult as extrapolations of other

The Air Force *Thor* (SM-75) intermediate-range ballistic missile, developed by Douglas, on its way to a target 1,500 miles away. Successful firing of the *Thor* was recently confirmed by the Air Force.

elements. In the operational employment of missiles themselves many other conventional Air Force elements must be brought into play. Thus a long-range or intermediate-range missile would be of limited use without Air Force target-system information, reconnaissance, and communication nets, all integrated under central control. Only with these can missile devices be efficiently meshed into the operations of present manned bombers so as to destroy with a minimum effort the most significant items of potential enemy resistance.

The Air Force missile program encompasses both ballistic and aerodynamic types of vehicles designed to cover many applications over both long and intermediate ranges. This program has been based upon a consistent philosophy systematically pursued over a long period of years. The Air Force mission in this field has been well understood, was reiterated in the Key West agreement reaffirming roles and missions of the three services, and further confirmed by the Secretary of Defense in his recent memorandum. This program has proceeded along lines of development demonstrated to be effective through past extensive experience with large airborne vehicles. This program has not been spectacular, but massive and sound. There is every reason for confidence that it will do the job well and on schedule.

Command and Control of Ballistic Missiles

by Brig. Gen. Charles M. McCorkle

During the past year intensive effort has been devoted to planning for the command and control of guided missiles. I would like briefly to point out some of the problems involved with this planning and to give a few personal thoughts on the likely evolution of command and control of ballistic missiles. By no means do I have all the answers. My primary purpose is to stimulate thinking on the subject.

It is significant that for the first time we are engaged in detailed operational planning for a weapon system that has not yet emerged from the development stage. There is no time to wait for the information we usually have when we plan for the introduction of a weapon into the air inventory. With very preliminary data we must begin to integrate ballistic missiles into the existing Air Force command and control structure, taking into account those unusual requirements stemming from the nature of the weapon.

Since command and control can mean different things to different people, perhaps it is necessary to establish a meaning for the purpose of this discussion. At the very least it must include general considerations of command channels, organizational structure, and the problems of operational control and coordination. Effective control by the commander is absolutely necessary if the ballistic missile is to fulfill its dual function as a deterrent to war and as a devastating weapon if war comes.

In planning for effective control by a commander we can subdivide our task along several lines: defining objectives, preparing plans and programs, developing a suitable organi-

zation, establishing policies and procedures, placing into effect a system of reporting, allocating personnel, carefully training and orienting personnel, and adopting strict inspection procedures. It is especially important for ballistic missiles that we establish a means of reserving to the commander final decision in all major undertakings.

We are making good progress in these tasks, but we have by no stretch of the imagination solved all the problems or fully explored all the ramifications these weapons bring to any consideration of command and control. Because there are still many decisions to be made, we must continue the same level of effort that we are applying to the accelerated development programs. The necessity for this approach was implicitly recognized when the responsibility for attaining the initial operational capability was assigned to the Air Research and Development Command along with its development responsibilities.

Differences and Similarities

Even without a great deal of study it becomes apparent that we cannot treat the command and control of ballistic missiles as though we were simply integrating additional bombers into our forces. The special characteristics of the missiles bring about a new operational environment and unique operational problems. The dispersed locations of the early units will pose problems of control that do not hamper the tightly knit operations of a compact air base. But I think that perhaps the most difficult problems we have to face are that the primary job of the ballistic missile organization is to *stay ready* year-in and year-out and that instead of "flying" most of the work will be "dry-running."

Not everything is new, however. Some of the problems of integrating the ballistic missile into our forces will be quite similar to those encountered in replacing the B-36 with the B-52. With the passing of any weapon system certain skills are no longer required and new ones must be developed. For years, in one way or another, we have been coping with this problem. Nor should we have too much trouble with many of the normal housekeeping functions. Men of the ballistic missile wings will certainly eat and sleep much the same as the men in other organizations.

The new *Matador* (TM-76), built by Martin, uses a booster bottle with solid-rocket propellant for initial takeoff. The bottle is jettisoned in flight.

It is in the operational control and logistics areas that we find the need for substantial departures from established practices. Such characteristics as quick reaction time, the ability to strike an enemy within minutes after launch, the capacity for a high rate of fire, and relative invulnerability once in the air lend a new significance to the ballistic missile.

First let us consider the operational control problem. The nature of the weapon and its potential as an instrument of national policy dictate that the command and control structure be immediately and entirely responsive to the highest national authorities. The initial use of ballistic missiles will likely be closely controlled by the President, both personally and by means of instructions governing actions under various conditions. This circumstance places certain restrictions and requirements on the command and control of ballistic missiles that do not generally apply to other weapon systems. We must be very sure that we are being attacked before launching the retaliatory ballistic missiles. The margin for errors in judgment or information is very narrow. It is with these ideas in mind that the general framework for command and control should be established.

Although ballistic missiles will bring new and powerful capabilities to the Air Force, I think it is necessary that we treat them as part of the family of long-range offensive weapons when considering their application to warfare. This is necessary because for a long time to come it appears that an optimum strategic force will have both manned aircraft and long-range missiles.

In order to gain maximum benefit from the several manned bombers and guided missiles the various elements must be employed with careful regard to coordination of attack. While each weapon has its peculiar characteristics, there are many factors which they have in common. They all have long range; they have heavy warheads for destroying large or hard targets; their design is such that they should be used in strikes at the heart of enemy strength rather than at his minor defenses; for best effect they must be employed in large numbers; they require central planning; and the target examination, evaluation, and assignment process is one that must be centrally and closely controlled.

These features indicate that, while ballistic missiles should have close attention by the highest national authorities, there is nothing which should preclude the use of the existing command and control structure of the Strategic Air Command. The principle of central control of all strategic systems remains valid. I think it is absolutely necessary that all uses of large nuclear weapons, except in the missions of air defense and close support of the surface battle, be coordinated by a central agency. Therefore I believe that the decisions which have been made assigning the ICBM and the land-based IRBM to SAC are wise.

Complications

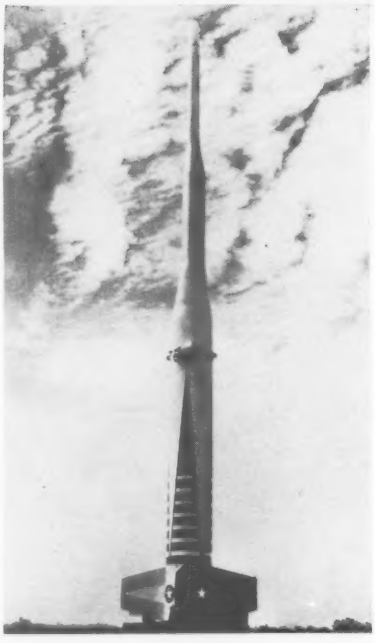
It is then necessary to examine the structure of ballistic missile command and control in light of two very fundamental ideas: first, close control by the highest national authorities and, second, incorporation

of the weapon into the existing strategic airpower command and control structure. After consideration of such factors as the effect of specific employment aspects, physical aspects, and support characteristics, it should be possible to determine just how much the existing strategic command and control must be modified.

As opposed to the general considerations mentioned previously, it is necessary to consider certain aspects in some detail. For example, when would ballistic missiles be used—only after an actual attack, or at some other unmistakable sign of aggression? This is not a decision which the military can or should make. It is a decision which should be made only at the highest level of government. Even though the military is not directly responsible for the answer to this question, I offer it as food for thought because we are directly concerned with the answer. In our basic planning for command and control we must build in sufficient flexibility to be able to accept various orders. For example, even if our first warning is the observance of hypersonic blips on Dew line radarscopes, we must be able immediately to launch a counterattack if our orders so dictate.

Since a very obvious advantage of ballistic missiles is their quick reaction time, we must take every precaution to protect our missile sites from crippling damage or destruction. There are two obvious courses we can follow here. The first possibility is to harden the sites so that any nuclear burst other than a direct hit would do relatively little damage. The cost of such a program runs into very high figures. The other approach is to provide protection by dispersal of our sites over wide areas. Although this is a cheaper method, it complicates the problems of organization, communications, and logistics. Initially we may depend upon dispersion to afford us the assurance that we will have a force-in-being at an early date. But there is no doubt that we must also eventually harden our bases to some degree.

The target complexes assigned to the early ballistic missiles must be compatible with their capability. Industrial complexes or large military



The Air Force X-17 test missile developed by Lockheed, provided the first and most comprehensive scientific data to be collected under actual environmental conditions that arise when a ballistic missile warhead reenters the earth's atmosphere.

concentrations are representative of the type of targets that can be most profitably attacked by our early ballistic weapons.

Another complex problem with which we are confronted is that we are unable to divert the ballistic missile after a very short time in the air: and of course the missile, once launched, cannot be recalled. This means, then, that we must have a very tight command structure that does not allow any mistakes. We are dealing here with decisions to be made in minutes rather than hours or days. We must balance the need to react quickly with the equally important need for a system of checks and balances which will prevent premature or accidental firings. Our command and control structure must be devised so as to make it immune to unauthorized firings—such as might be accomplished by saboteurs.

Several other physical aspects of the missile are important to a consideration of command and control. The inability of the missile to tell us what it did after being launched presents a problem. Based upon launch reports, radar track reports, and any other information he can lay hands on, the ballistic missile commander must decide whether enough missiles have been sent against any particular target. This points to the need for concurrent work in reconnaissance systems that will help tell us what the enemy is up to and what our missiles and aircraft are doing to him. Information of this kind will permit us to make much better use of a mixed force. For example, we might want to send several ballistic missiles against a target, knowing that the chances were against a good hit. But we might do it anyway in an effort to avoid high risks to our bombers. Yet without some kind of intelligence as to what happened to the missiles we would not be in a very good position to make a decision as to whether to follow up with bombers against that particular target.

Closely related to this problem is the difficulty of shifting the missile aiming point to any of a large number of targets. This creates the need for more detailed planning than is required for the manned bomber. Sequencing arrangements must be worked out well in advance to cover numerous operational situations.

A Matter of Logistics

Earlier I mentioned that in the logistics area we should expect to find the need for substantial departure from established practices. Since only a very small part of the workload of ballistic missile organizations will be "flying" and the greatest share will be keeping ready, command and control must reflect this situation. I think it is apparent that logistics will be more important to ballistic missiles than to manned aircraft. The aircraft can usually absorb a large number of malfunctions and still complete its mission or return home. Not so with the missile. We must begin to exploit all the newest techniques and methods developed in the field of logistics. For example, the use of electronic data-processing equipments and methods seems to have great potential for coping with the complex problems of supplying and maintaining ballistic missiles. This system should give the commander a much firmer control over his logistics than he has had in the past.

Communications requirements will be of far greater importance and larger magnitude than any system we have today. The communi-

cations system must be capable of handling a vast flow of information in a very short time. It must react instantaneously and transmit orders from one side of the country to the other in a matter of seconds. In addition there must be a backup system depending upon another entirely different means of communication. We may even need a backup for the backup. All of these systems must be completely tamperproof to prevent unauthorized orders precipitating a nuclear war. Without assurance of an effective and rapid communications system, any talk of a quick-reaction weapon system loses a great deal of its meaning. And still we must be prepared to act under prearranged orders in the event communications are knocked out in spite of all our precautions. In effect, we must have a completely foolproof communications system.

The actual sites chosen for the ballistic missile launch areas will have a serious effect on the command and control structure. It is reasonable to assume that Strategic Air Command strike bases would be a prime target of Soviet attack. We cannot afford to site our ballistic missiles on or very near these particular bases. But because of tremendous logistics problems we cannot afford to place them in a wilderness. For this reason and for economy considerations we must compromise and site ballistic missiles near enough to existing military bases so that logistic support is comparatively easy, but still far enough away so that an attack aimed at the base will not destroy the missile launch area.

I have mentioned earlier the problem of maintaining an alert status month after month, year after year. It is worthy of special note that the ballistic missile commander will encounter some fairly difficult personnel problems as a result of this type of operation. Keeping skilled men and maintaining morale in the face of boredom will require exceptionally qualified commanders. Capturing and developing the elusive esprit de corps will be one of their most important jobs.

Command and Control Structure

Now that I have touched on some of the major factors that will affect the command and control of ballistic missiles, I think it appropriate to consider how our command and control structure could be formulated. To get a clearer picture of what the organization of our ballistic missile structure should be, I want to make a few necessary assumptions:

That we can develop and produce the necessary communications net for the use of Strategic Air Command.

The Air Force *Bomarc* (IM-99) area-defense ground-to-air intereceptor missile developed by Boeing, is now in production. It has a range of over 250 miles and is capable of destroying enemy aircraft while they are still far from their targets. Advance version, with greatly increased range, will be propelled by solid fuel simplifying logistics and minimizing reaction time.

That the President only will be authorized to direct an attack, either directly or by standing order.

That the missile sites will be widely dispersed.

That the personnel and logistics problems can be solved.

That targets will be assigned.

So far nothing has developed which demands that we throw out the conventional organizational plan of air forces: air divisions, wings, groups, and squadrons. Perhaps it will be necessary to make some revisions in nomenclature, but in the main I think the organizational theory will still apply. Initially I visualize a ballistic missile air divison consisting of wings, each with several squadrons. As additional missiles are phased into the inventory, additional wings could be activated. When the quantities of ballistic missiles are sufficient, the entire ballistic missile organization could be placed under the commander of a numbered air force whose sole mission would be the control of ballistic missiles. This concept differs somewhat from the concept that intercontinental air-breathing missiles should be integrated under the same commander who commands manned aircraft.

There are proponents of this latter concept who would extend it to include ballistic missiles. Under this proposal a certain number of ballistic missiles would be assigned to each numbered air force of the Strategic Air Command. Their belief is that integration of these missiles will bring familiarity throughout the Air Force with these new weapons and the transition period will be covered more easily. My own view is that the ballistic missile is so different from other strategic systems in its operational characteristics that it must have special treatment. This can be offered best by a separate controlling organization.

One important aspect is that operational control of actual directions for launching must be placed high in the chain of command. If we are to use effectively the short reaction times being developed into the system we cannot possibly depend upon a system of relaying commands to numerous points in the organizational structure. This becomes even more apparent when we consider the

problem of coordinating attacks of other weapons.

One exception to establishing ballistic missiles under separate Air Force commands could be the IRBM. It does appear reasonable to place the overseas elements of this missile under the command of the local Strategic Air Command numbered air force.

Timing

Both for the ICBM and the IRBM we must remember that the manned system and the air-breathing missile system have a longer time of flight to the target area. We must assure ourselves of close coordination between attacks by these forces, with their various characteristics, so that we avoid the possibility of destroying part of our own attacking forces. We must be careful to ensure coordination of attack so that our first wave of supersonic, intercontinental cruise missiles is not destroyed by the explosions of subsequent launchings of intercontinental ballistic missiles. We must bear in mind that the principle of coordination of attack applies nowhere more completely than in air warfare involving strategic weapon systems. We will have to develop means of concentrating our attacks on the various target complexes with minimum danger to the ensuing attacks. I do not visualize one single attack but a series of hammering attacks throughout the first several hours of war.

A possible solution to the time schedule for this problem is to launch intercontinental ballistic missiles against targets deep in enemy territory. After a few hours the ballistic missile attack would cease, leaving a short period for the initial wave of supersonic cruise missiles to make their penetration to their assigned targets. These missiles would be followed by supersonic manned aircraft, hitting targets of shorter range or flying through corridors between atomic clouds. Following these supersonic manned aircraft would be the remaining portion of our force: the subsonic manned aircraft and subsonic missiles.

After the last wave of subsonic aircraft has departed for their bases the ballistic missile attack would commence anew, to be followed by the second wave of supersonic missiles and so on until our entire weight of attack has been laid down.

In summary, these are the elements we must have in an effective command and control structure for ballistic missiles:

☆ A safe, dependable, and rapid communications system.

☆ A time-phased plan for the use of ballistic missiles in conjunction with other weapons.

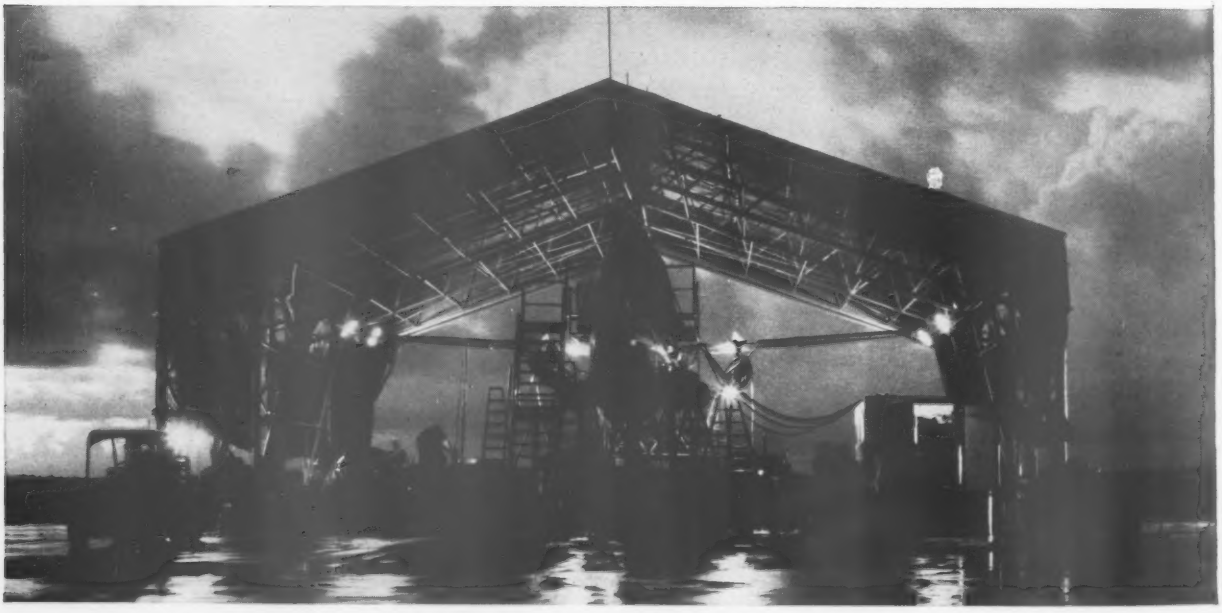
☆ A tight, well-knit command structure running from the highest national authorities to the launch position.

☆ A well-trained, dedicated nucleus of personnel upon whom the effectiveness of the launch operation will depend.

☆ A logistics system which is entirely responsive to the stringent demands of the weapon system.

☆ An effective means of maintaining esprit de corps in the missile organization.

Our problems are difficult but not insurmountable. Many of the problems we faced a year ago have been solved. No matter how they are finally settled, it is clear that the ballistic missile is arriving fast, that it is a potent weapon, and that it is here to stay. In the command and control function it will demand of our leaders and planners imagination, objectivity, and a freedom from preconceived ideas that can only be compared with the demands made upon military men when they first became the possessors of our old friend the airplane.



Airmen of the 6555th Guided Missiles Squadron, Patrick AFB, Fla., start early morning checkout of the *Snark*.

THE RASCAL

SUNDAY PUNCH FOR THE MEDIUM BOMBER

by T/Sgt. John K. O'Doherty

In high-altitude tests direct hits were recorded on 1,500-foot targets.

THE first strategic, air-to-surface operational missile in the Air Force arsenal of modern weapons made its dramatic debut in late October when the Strategic Air Command formally accepted delivery of the *Rascal*. The new missile, officially designated GAM (Guided Aircraft Missile)-63, brings additional offensive capability to the long-range medium bombers of SAC, and illustrates vividly the complementary role of the man and missile in the contemporary airpower picture.

Basically, this extra punch now added to SAC's already formidable firepower is a winged, rocket-powered aircraft measuring 32 feet in length and four feet in diameter. It is suspended alongside the body of a Boeing B-47 *Stratojet* bomber by a special pylon attached to the fuselage. When launched in flight by the *Stratojet* crew, the *Rascal* is guided at supersonic speed to the target—many miles distant from the launch position of the mother aircraft. The missile may be equipped with a nuclear warhead.

The *Rascal* is a refined and sophisticated descendant of the series of research aircraft which began with the X-1, developed for the Air Force by the Bell Aircraft Corporation. The rocket-powered Bell X-1 was first to pierce the sound barrier in 1947, and the succeeding X-family of rocket-research aircraft provided the scientific background from which the concept of the *Rascal* evolved. The first Air Force GAM-63 squadron, now organized in SAC, will use flight simulators, checkout procedures, and other training aids specifically designed for the *Rascal* to insure combat effectiveness and technical proficiency of crews.

Characteristics of the *Rascal* teamed with the capabilities of the B-47 provide this unique man-missile combination with a Sunday punch against heavily defended targets. The B-47 *Stratojet*, a medium bomber, attains a speed in excess of 600 m. p. h., and its range is described as 4,000 miles. This range of operation can be extended considerably by the use of aerial tankers for refueling. A B-47 of the 43rd Bomb Wing remained in the air over Europe for 47 hours and 35 minutes covering a distance of 21,163 miles in November 1954.

Thus the B-47, operating from SAC bases in the United States or overseas, can place the *Rascal* over any target in the world. While a single missile delivers destructive power in excess of the multi-plane raids of World War II, the bomber retains for itself a comfortable cushion of airspace as protection against anti-aircraft fire or other air defense measures taken by the enemy. The speed and altitude of the missile render intercept, in the present stage of air defense development, virtually impossible.

It has been logically pointed out that all long-range missiles contain a fault in that they lack the capacity for intelligent, independent action in the face of changing circumstances. In the case of the *Rascal*-B-47 combination a compromise is reached whereby the human intelligence and the impersonal attributes of the missile are both utilized to advantage. The pilot of the bomber and his launch crew can "think" the missile into position just seconds away from the target—and from this point forward only the electronic brains of the machine are necessary for completion of the mission. If circumstances should dictate that the bomber divert to a secondary target—or even to a target of opportunity—the human intelligence retains the initiative up to the point where a rewarding strike is assured.

The supersonic *Rascal* with its power-packed warhead is the forerunner of other technological advances scheduled to augment the striking power of the USAF's Strategic Air Command.

"Missiles are indispensable to the combat structure of the Air Force," said Chief of Staff, General Thomas D. White, during a recent speech at Washington, "and we will continue to integrate them with manned aircraft to improve our operational capabilities as rapidly as possible."

The combination of the piloted B-47 and the inanimate *Rascal* epitomizes the role of the missile as a worthy supplement to the capability of manned aircraft through the foreseeable future. As SAC steps out in front with a reasonable approach to the perfect weapon — the missile that thinks — new versatility and flexibility are added to the power of the United States Air Force.

USAF VISIT TO

To help celebrate Argentina's 12 Annual sample of its airpower for our Lat Americ At Buenos Aires and Rio de Ja o, sever and

Gen. Curtis E. LeMay (second from right), U. S. Ambassador Willard L. Beaulac, and Brig. Gen. Alfred Juan Vedoya (right), Commander-in-Chief, Argentine Air Force, troop the line upon the USAF Vice Chief of Staff's arrival in Buenos Aires after record-setting 6,350-mile nonstop, no-refueling flight to the Argentine.

Capt. Matthew R. Briggs, Jr., C-130 aircraft commander from the 772d Troop Carrier Sq. at Ardmore AFB, Okla., briefs Argentine newsmen on the Lockheed transport's operations.

Air Force personnel participating in Aviation Week at Buenos Aire take time out to carry candy and toys to a local children's hospital

The largest crowd in the history of Argentina to witness an aviation exhibit queues up at Ezeiza Airport to see static displays of USAF aircraft.

With an assist from a Thunderbird crew chief, Argentine President Pedro Aramburu's young son gets a close look at an F-100F *Super Sabre*

→

Little Latin Americans clamber up loading ramp to inspect the inside of a Douglas C-124 *Globemaster II* at Ezeiza Airport, Buenos Aires.

T-TO SOUTH AMERICA

Annual Aeronautics Week (Nov. 10-17) the U. S. displayed a American "good neighbors."

, several million Argentines and Brazilians saw USAF aerial and ground displays stress airpower's role in the missile age.

In a highlight of the week, a Boeing KC-135 *Stratotanker* landed at Buenos Aires after a historic flight from Westover AFB, Mass., then set a record on its return trip. The *Stratotanker* was commanded by USAF Vice Chief of Staff, Gen. Curtis E. LeMay, who carried a letter from President Eisenhower to President Pedro Eugenio Aramburu, citing the long-range flight as a sample of the program in communications which "is making relations between members of the family of American states ever closer and stronger."

It was a "homecoming" for General LeMay who participated in a 1937 goodwill formation flight of Boeing B-17 *Flying Fortresses* to Buenos Aires. The following year a second Argentine flight brought his group the Mackay trophy.

Climaxing Aeronautics Week, Brig. Gen. W. K. Martin led six Boeing B-52 *Stratofortresses* in a 10,425-mile nonstop flight from Florida to the Argentine capital, and back to the U.S. Two days later, the USAF flew to Rio for another show.

One reason for the shows was explained in a statement made by Secretary of the Air Force James H. Douglas. "Latin American countries," he said, "have an abiding interest in problems of hemisphere defense . . ."

Our participation in the Aeronautics Week observance in the Argentine capital and in the air show at Rio enabled people of Latin America to view some of the aircraft which the U.S. has produced to meet threats of aggression in this hemisphere and in other parts of the free world.

Capt. William H. ("Scotty") Scott checks parachute fit for President Pedro Aramburu prior to giving him a faster-than-sound flight in a North American F-100F *Super Sabre*. President Aramburu thus became the first president ever to break the sound barrier.

T/Sgt. "Doug" Bullington, Lockheed C-130 flight engineer from the 772d Troop Carrier Sq., Ardmore AFB, Okla., explains *Hercules* instrument panel operation to Sarieto Prieto and Julie Lopez of Buenos Aires.

A/1C Frank Rocco, 809th AP Sq., MacDill AFB, Fla., gives admiring Argentine youngsters his autograph. Friendly Latin Americans made every U. S. airman feel like a Hollywood movie star.

Air Force Thunderbirds perform at Rio de Janeiro's Copa Cabana Beach before half a million Brazilions.

→

Record Jet Flight—13 hours to Buenos Aires; 11 hours 5 minutes return.

COURTESY OF THE N.Y. TIMES

El Escorial, the former royal residence near Madrid, was built by Philip II in 1563. It comprises a massive palace, monastery and church; contains royal tombs and a fine collection of Spanish paintings.

Spain

DUTY IN SPAIN CAN BE "ROUTINE" OR AN UNFORGETTABLE EXPERIENCE. THE CHOICE IS YOURS.

by Maj. Normand H. Traverso
Joint U.S. Military Group

THE KEY to successful living in Spain is a healthy mental attitude. There are any number of people presently working with the Air Force in Spain who deplore their assignment; however, most of them have accepted Spain as it actually is—uncolored by prejudice or vistavision imagination—and have adapted themselves to their surroundings. These people are thoroughly enjoying their tour of duty.

There can be little doubt that the first six months of adjustment to Spain are difficult. Strangeness of a new country, compounded by problems associated with temporary living facilities, awaiting household goods, locating a permanent residence, and a multitude of other little items do not ordinarily make the initial introduction to Spain a cheery one. Add to this the frustrating experience of being unable to communicate with the Spanish people, and you have all the ingredients necessary to form adverse opinions about duty in Spain. Fortunately, however, these early problems are temporary in nature and time alone solves them. But to intolerant people, the molehill mountain climbers, these first disheartening experiences remain uppermost and continue to plague them throughout their tour of duty.

The choice is the individual's. Three airmen, who were disappointed upon arrival in Spain, chose to forget their first impression and take advantage of the excellent trout fishing streams and lakes in Spain. Within three hours drive of Madrid, they packed in on mules and horses to a small volcanic lake teeming with rainbows and brownies. In pine country reminiscent of California mountain areas, the airmen shared with the Spanish lake guard a weekend of pure fishing enjoyment where 15-inch trout were common and the big ones anxious for the lure.

Flamenco dancing—intricate and flamboyant—no longer poses a challenge to groups of wives who have hired dancing teachers and can now tell a story in dance. Hunters looking for new thrills can test their shooting skills against the wily, fast-moving, deceptive "perdiz," a bird that belongs to the partridge family.

Artistic-minded persons can study under the tutelage of well known artists and view the priceless masterpieces of Spanish, Flemish, and Venetian schools in the Prado, the national Spanish museum of painting and sculpture in Madrid. In Barcelona, one has the choice of 12 museums covering all periods. The fellow with a yen to play the guitar for male songfests can purchase some of

COURTESY THE N. Y. TIMES

the world's finest guitars and with relatively small investment hire a teacher. Spanish clubs offering limited golf, tennis, swimming, horseback riding, and other sports facilities have opened a small number of their memberships to American military personnel. Spain's mountainous terrain provides excellent picnic sites in the summer and skiing during the winter, all within easy driving distance of the new USAF installations.

There are also numerous other attractions in Spain ranging from opera and ballet to dining and dancing to good music that Americans stationed here are fully enjoying. Although living expenses in Spain are rather high, many of the normal Spanish activities away from the main streets and flashy nightclubs are relatively inexpensive. The fact that virtually every major city in Spain is within a day's driving distance, gives military personnel an opportunity to participate in such gala fiestas as Seville's "Feria," Valencia's "Fallas," and the running of the bulls through the streets of Pamplona, or take interesting, historic tours.

Everyday living in Spain is not essentially very much different from living in the United States. At present, there are few government quarters available and most of the American military population is integrated into the local Spanish communities. Although housing availability has, in some instances, formed "little Americas" in the community, military personnel can also be found scattered throughout the cities and suburbs, living in fashionable city apartments and comfortable country homes.

Housing is undoubtedly the most difficult problem facing the new arrival in Spain. The difference of Spanish architectural style and kitchen equipment at first gives pause to American housekeepers. They prefer to investigate the possibilities of new housing being constructed under an extensive governmental and private building program. The newer apartments and house are modern in design and tend toward American styling with combination living-dining rooms, larger kitchens, and permanent closets. These units are naturally preferred by Americans but unfortunately, are available only in limited numbers and they usually command a higher monthly rental.

On the other hand, some of the housing built within the past 10 years offers a combination of Spanish architecture blended with modernity which is suitable and adaptable to American taste. These units usually have more but smaller rooms giving a chopped-up appearance to the house or apartment. Householders initially ignore these units in their quest for something typically American, but learn after a while that they can be modified to their taste.

One room common to all units is the maid's quarters. In Spain, maids are a necessity required by the Spanish mode of living and shopping peculiarities. They are very helpful, particularly in housekeeping chores. One of the principal advantages of having a maid is in shopping since there are no supermarkets in Spain and shopping for the family groceries can become a tedious task. Bread, for example, can only be purchased in a bread store, cake in another shop, fruits and vegetables elsewhere, and so on down the list. Practically every item requires a trip to a shop specializing in that commodity. Staples, canned goods, and meats can be purchased in the commissary and base exchange, but only by Americans. The remaining foods, principally fruits, vegetables, and fish must be bought on the Spanish market. It is not uncommon for American housewives to spend the major part of a day going hither and yon for foodstuffs.

Starting wages for maids now are approximately $8.70 monthly. Compared to the United States, this immediately appears to be a bonanza, but there are added costs which mount up. Directly or indirectly a maid will cost approximately $50.00 monthly when food, uniform, accident and health insurance, vacation, cosmetics, and other incidental expenses are tallied. There are a few families that have foregone the joys and sorrows of having a maid, but the majority of Americans in Spain, regardless of rank and income, can afford at least one maid or general housekeeper. For baby sitting purposes alone, they are well worth the cost.

Another feature of Spanish domestic help appreciated most by the American women is the hiring of seamstresses. Normally, for 80 cents to a dollar a day plus two meals, a Spanish seamstress will come to the

Madrid residents pay homage to the Patron Saint Isidro with a recital of typical Spanish dances during a fiesta in front of the town hall.

house and make clothes for the children as well as for the lady of the house. Clothing is a prevailing problem for all members of the family. Although the base exchanges carry a limited stock of clothing, many families must depend upon stateside mail order houses for materials or readymade clothes. Items in the normal wardrobe wear out more rapidly in Spain due to the vigorous laundering methods which decrease the durability of clothes. Because civilian clothing is worn almost exclusively for frequent social occasions with Spanish and American companions, duty in Spain requires a more varied wardrobe than a ZI assignment.

Obviously, there are drawbacks to Spanish living customs just as there would be in any foreign country when compared to the American standards we are accustomed to. These aren't major items, but a series of small differences which become relatively unimportant once the American has fully adjusted himself to the tempo of living in Spain. This usually occurs when the American realizes that he is the foreigner in Spain and (as we would expect foreigners in our country to make normal adjustments to our ways) has adjusted accordingly. This simply means that he needs to be tolerant and understanding.

There is also a "mañana" attitude in Spain which causes some inconvenience to American and Spaniard alike but is tolerated with resigned amusement by the Spaniards. This attitude doesn't arise from a national characteristic of laziness because Spaniards are hard workers. It comes from an old economic principle of supply and demand — plus some transportation difficulties.

Assume for instance, that an elbow joint in the plumbing broke. Chances are the plumber would come the same day you called him, but, after surveying the problem, he might not make the necessary repairs for a day or two. It would be perfectly natural to become exasperated to the point of apoplexy. If you looked into the matter, however, you would probably find that the plumber had to scout around to find the replacement part or order it from a distributor located on the other side of the city. There are few fast delivery trucks in Spain. More likely some youngster will get your part to the plumber via trolley, bus, bicycle, on foot, or a combination of all four. All of this takes time and usually a "mañana."

The allusion to the plumbing difficulty is also applicable to other conveniences of everyday living and comfort. Car parts, particularly for the late model American automobiles, aren't normally available on the Spanish market. To get them you would have to order from the States or trust that base exchange garages in Germany or North Africa might have them in stock.

Travel in Spain is paradoxical in that there is much less road traffic and driver fatigue from this hazard is

A typical residential area in Madrid. U. S. Air Force personnel and their families have been living in Spanish houses and apartments.

Civilian clothing is required when off duty and off base.

sharply decreased. Offsetting this advantage, however, is the condition of the main highways, which are predominantly rough, curving and usually two-lane. A 100-mile trip, which would normally take two hours on U.S. roads, takes three or three-and-a-half hours in Spain. Even if road conditions were perfect, it still would be more prudent to drive at a moderate rate of speed to retain full control of your vehicle and avoid donkey carts hidden around curves, bicycles or motorcycles riding in the center of your lane, and stalled trucks parked on the highway. It is mandatory, not only militarily but individually, to learn the art of defensive driving in Spain, where the man on the right has the right of way and usually takes it regardless of the dangers involved.

An assignment to Spain must be considered among the better assignments offered by the Air Force. It has its good features as well as its bad ones, but principally it allows each person in Spain to live right in Spanish communities as neighbors and friends. Spain and its people require neighborly understanding to look beyond the surface and see the warmth and friendliness in their character.

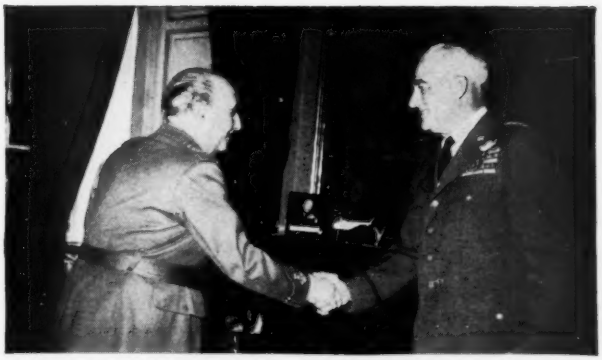
Spaniards respect America's technical know-how, but rightly resent brash Americans' constant reminders that "in America we do it this way" or some other trite saying that implies American superiority. Spaniards also know what is best for Spaniards and they accept modern methods as best suits their country and customs and reject the rest. This is visible today in Spain's efforts to improve its industry, transportation, housing, communications, and so on.

There is a transition phase between American and Spanish culture which each individual must accomplish before full enjoyment of living in Spain can be realized. Every new assignee to Spain is given personal assistance in this transition by an older American resident who acts as a sponsor to the newcomer. The sponsor helps the new assignee prepare for his move overseas, meets him upon arrival, secures temporary lodgings, aids in locating permanent quarters, and generally acts as guide and interpreter until the newcomer is accustomed to his new surroundings.

The military units provide free language instruction for their personnel during duty hours so they may acquire the basics of the Spanish language. Dependents can also participate in this training or hire local teachers for private instruction in their homes. The importance of speaking Spanish is obvious because it is the complimentary key to greater understanding and increased enjoyment of the duty tour in Spain. There is bound to be contact with Spaniards in the home, during duty hours, on vacation trips, and in daily travel about the community, and the wise individual prepares for these contacts by studying the language.

In the final analysis, the individual makes or breaks his duty tour in Spain. You can remain provincial and refuse to accept anything that doesn't have "made in America" stamped on it. Or, you can acquire an international viewpoint and realize that many of the cultures you will be exposed to on the European continent, and particularly in Spain, are keystones of our American culture.

The choice is yours.



General Francisco Franco greets General Twining during an official visit at Madrid last April.

Workers put finishing touches on 485-mile petroleum line.

Madrid's military museum contains one of the world's finest collections of armor.

AIRMAN'S WORLD

MIXED EMOTIONS

USAF Ground Safety officials are viewing early 1957 traffic casualty reductions with reservations as the holiday season approaches.

Through the end of August, highway fatalities dropped eight percent from 1956 figures, but officials at USAF Hq were reluctant to predict that the complete figures for this year would actually show an improvement over the 612-death total of a year ago.

They were quick to point out that increased holiday travel and adverse driving conditions could combine to wreck the improved record. Past experience has proven December's highway-death average will be as high as 20 percent above other months.

As a guide to holiday travelers, officials cautioned against the three most prominent highway killers—exceeding the speed limit, driving too fast for existing conditions, and fatigue. These three alone account for more than 75 percent of all holiday mishaps. Additionally, the use of intoxicants is indicated in one of every three holiday accidents.

The plea—let's make this Christmas deathless.

★ ★ ★

RECORD HOP

USAF has been participating in a private record hop with aircraft dancing to new speed and distance marks around the globe.

☆ Vice Chief of Staff, Gen. Curtis LeMay, started it with a 6350-mile, nonstop leap to Buenos Aires, Argentina in a Boeing KC-135. After a one-day layover, General LeMay piloted the same aircraft back to Washington in 11 hours.

☆ Douglas B-66 bombers from TAC flew an 8500-mile, nonstop, aerial-refueled mission from California to the Philippines.

☆ Boeing B-52s spun a 10,600-mile, nonstop hop from Florida to Argentina and return, also using aerial refueling.

☆ Jet fighters streaked from coast-to-coast and return hanging up three new speed records. McDonnell RF-101 *Voodoos* set a west-east record of 3 hours, 5:39.2; east-west, 3 hours, 34:08.8; and round trip, 6 hours, 42:06.9.

☆ Out in the Pacific, *Voodoos* established a new Tokyo-Honolulu time one day, only to see North American F-100s smash it the next by 14 minutes with a 6 hour, 21 minute run.

☆ Maj. Adrian Drew this month recaptured the Thompson Trophy and world speed record with a 1,207.6 m.p.h. *Voodoo* flight.

ACCIDENTS WILL HAPPEN

USAF does everything in its power to avoid aircraft accidents, but in spite of all efforts, they will happen. Three airmen at Wheelus AB, Tripoli, recently devised a method of relieving congestion resulting from minor runway mishaps.

From past experience M/Sgts. Cecil Shepard and Ocie Tekell, and A/1C John Rohm have learned that a blown tire or a locked brake can spell lengthy tie-ups, particularly on stations with only one operational strip. As a result the trio got their heads together and came up with a simple solution costing approximately $150 which allows a disabled aircraft to be speedily cleared from a runway.

Using a pair of Boeing B-29 nosewheel struts and salvaged material, they fashioned them for mounting, either singly or in pairs, to the main gear of a North American F-100.

The new portable assembly can be mounted by three men, the disabled aircraft moved, and the runway reopened in less than 12 minutes. Under the old system it took four men from one to three hours to do the job by removing wheels and brakes. Through use of salvaged gear from other aircraft, the inventive trio feel that similar gears may be fashioned for almost any type plane.

Tying up single-strip air base operations for prolonged periods can be expensive in several ways. It can force pilots of aircraft preparing to land to either seek an alternate base or bailout. The saving of a single aircraft or reduction in risks of pilot injury alone justifies use of the makeshift gear.

ANOTHER BLACK BOX →

A black box with a new twist has assumed an important role in teaching aircraft recognition to the personnel of 512th Fighter-Interceptor Squadron at RAF Bentwaters, England.

A complex maze of resistors, relays, and condensers have been arranged to flash colored slides of aircraft on a ground glass screen when triggered by a pilot. Aircraft of every nation are included in the selection.

As the slide flashes, the plane appears for a three-second interval, and the operator must determine whether it is friend or foe. If the latter, he presses a second button which theoretically shoots the bogie down. If the aircraft was an enemy, a big hero medal lights; if not, the box emits a mechanical version of a Bronx cheer.

The apparatus, dubbed The Black Box, was designed and built by Capt. J. A. Daugherty, electronics officer of the 512th.

★ ★ ★

TV FARE

"Telephone Time," one of ABC-TV's leading network shows, is in the process of shooting "The Tyson Story," a half-hour film based on the thrilling Pacific flight of a MATS transport. Shortly after passing the point of no return, the USAF plane lost one engine, and minutes later, a second. The finished script is an excellent product which will keep viewers on the edge of their chairs. No broadcast date has been established.

Also in the production stage is a pilot film for a proposed series on the Flying Tigers and their escapades in the CBI during WW II.

★ ★ ★

YOU'LL GET A CHARGE

When a two-hour chore is reduced to a ten-minute task, that's news. But when that ten-minute task often eliminates the need for performing the two-hour chore—that's headline stuff.

For the second time this month, Wheelus AB, Tripoli mechanics have scored with a time-saving, job-eliminating improvement. (See "Accidents Will Happen") Now, A/1C George Jackson, 431st Fighter-Interceptor Squadron, has scored with an electric circuit checking device.

In the past, a trouble-shooter, checking a jet aircraft alternator regulating system, could never be certain whether it was the alternator, regulator, or circuit which was at fault.

Mechanics had to fire up a jet to check voltage in the alternator. If the reading was abnormally low or none registered, a continuity check of the circuit was dictated. If no open readings were found, the regulator was replaced. And then, if that didn't solve the problem, the alternator was replaced. Many times this final step proved to be unnecessary.

But it was the final step that set Airman Jackson to work. To remove and replace the alternator, it was necessary to remove the entire tail section and engine, replace the alternator, reinstall the engine and aft section, and run up the plane at least twice more.

Jackson devised a test harness which can be plugged into an auxiliary power source at one end and the alternator system at the other. A simple voltage check reveals whether the problem lies within the alternator or elsewhere in the system.

Aside from the time-saving aspects of the improved checking device, a further saving was realized by the elimination of removal and replacement of serviceable parts. Additionally, the employment of this simple device has improved flight-line morale immeasurably by doing away with what often was an unnecessary and tedious job.

★ ★ ★

GLOW LITTLE FLIGHT LINE

A forthcoming revision to T. O. 35-1-3 will require reflectorization of ground equipment in use on flight lines and is expected to provide greater safety in after-dark operations. The revision is a direct result of pilot shop studies at Moody AFB, Ga.

Flight line obstacles and equipment will be outlined with a four-inch band of paint and reflectorizing beads—similar to that in use on night highway signs—to assure more ready identification for crewmen in taxiing aircraft.

HASH MARKS TO GO

An in-the-mill revision to AFR 35-50 will become official next month and replace service stripes (hash marks) with a new service ribbon.

The revised regulation, which will bear the numerical designation AFR 900-10, will contain detailed criteria and instructions for wear. This will be the first time a symbol indicating length of service has been available to commissioned USAF personnel. No accompanying medal will be issued.

The ribbon will be Air Force blue with four lighter (turquoise) blue stripes, two at each end spaced a quarter-inch apart. Basic issue will be for four years' honorable service. A bronze oak-leaf cluster will be awarded for each additional four years, and a silver oak-leaf cluster for each five bronze.

The ribbon will be ready for issue by March 1958.

★ ★ ★

ANNIE OAKLEY?

A modern Annie Oakley in Air Force blue—an apt description of Air Force nurse, Lt. Ruth Blickensderfer.

Stationed at Ernest Harmon AFB, Newfoundland, Lieutenant Blickensderfer is qualified as a small arms expert with .22 and .38 calibre revolvers and the .45 calibre automatic pistol as well as a hypodermic needle. One of the few women representing the USAF at national matches in Camp Perry, Ohio this summer, she placed sixth among 130 entries in small arms competition.

The lieutenant is an active member of the Rod and Gun Club at Harmon. (See THE AIRMAN, November, "Tally Ho, The Fox.")

BLUE NOTES

Traditionally music has always had its place in military life. Every branch of the service has songs and marches which have lived through generations in its history.

The Air Force, a comparative newcomer to the martial ranks, lacks the large number of traditional tunes possessed by the older sister services. Consequently, Brig. Gen. and Mrs. W. K. Martin recently decided to make a concerted effort to improve the service song situation USAF-wide.

Mrs. Martin spearheaded the establishment of a $350 special fund at Loring AFB, Maine, where her husband commands the 45th Air Division. The prize fund was offered to base personnel and their families for original music and lyrics.

The final result was more than two dozen new tunes constructed about an Air Force theme. Three members of the USAF Band served as final judges for the contest: Lt. Harry Meuser, assistant conductor; M/Sgt. Fred Werle, chief arranger; and S/Sgt. Serge de Gastyne, arranger and composer.

Mrs. Ruth Hutchinson, wife of Maj. Phillip Hutchinson, walked off with the two top prizes for her "Air Force Blue March" and a hymn, "Oh, Men Who Fly."

These two and the third and fourth place tunes, "Silver Wings" and "Men of Distinction," will be presented in the near future by the Air Force Symphony Orchestra on its nationwide, transcribed radio program, "Serenade in Blue."

★ ★ ★

$64,000 ANSWER

Six weeks of work and a $3 gimmick have won a Commendation Ribbon for M/Sgt. James Thomas, 36th Fighter Day Wing, Bitburg AB, Germany, and promises to save the Air Force thousands of dollars annually.

Thomas has perfected and placed in operation a 20 mm. gun-circuit tester which is being manufactured by AMC and is to be distributed to USAF units worldwide.

The circuit tester, which looks like a combination shoehorn-flashlight, is seven inches long and may be slipped easily into a pocket when not in use. It replaces the tester formerly in use which was seven feet long.

In the new device, a copper contact plate is imbedded in one end of a phenolic block, a hardy, nonconductive, fibrous material. The opposite end boasts a test bulb. A connecting wire and resistor are housed within the block. The contact is placed against a gun's firing pin, and if the bulb lights, there is proper voltage level present. If not, the gun obviously is not in working condition.

Official sources claim the tester will save an estimated $10,000 a year for the 36th alone. North American Aviation, Inc., builders of the F-100 *Super Sabre* used by the wing, have reportedly been working on a similar device for more than two years and value Thomas' tester at $100,000.

★ ★ ★

THE TOWN COUNCIL

Mobile-home residents at Bolling AFB, Washington, D. C., have formed a five-man board of directors which functions as a town council for their community.

In addition to normal governing duties, this group also functions as the comptroller for the town's funds. Each resident is assessed $18.50 monthly for the 40- by 60-foot lot on which his trailer is parked. Six dollars of this fee is paid to the government for use of the land. The balance goes into the town fund and is allocated at the discretion of the board.

In the past, monies from this fund have been expended for playground and recreational activities; janitorial services; auditor services; utility bills; and the maintenance and replacement of electric washers and dryers used by the community residents.

Since July the council has awarded a "Mobile Home of the Month" plaque and $10 prize to the most outstanding trailer in the park.

Net result of the entire operation has been an increased interest in local community affairs within the development.

AIR AGE LIBRARY

Air Force Airs, by USAF T/Sgt. William Wallrich (Duell, Sloan and Pearce, $2.95). Contains a unique selection of songs, ballads, and parodies produced by airmen through three wars. First Air Force song book ever published.

Tom Pittman, USAF, by Rutherford Montgomery (Duell, Sloan and Pearce, $3.00). The magnificent story of the determination and courage of an Air Force B-47 pilot, his Arctic crash, survival, and fight to return to combat status.

Air Spy, Constance Babington Smith, (Harper and Brothers, $4.00). Nonfiction story of photo air reconnaisance in WW II. The author, a photo interpreter for the RAF during the war, was decorated for the discovery of German V-2 sites.

The Making of a Moon: The Story of the Earth Satellite Program, Arthur C. Clarke, (Harper and Brothers, $3.50). An account for the layman of Project Vanguard, and related areas such as satellite orbits, space stations, and military implications of space travel.

Earth Satellites, Patrick C. Moore, (W. W. Norton, $2.95). A history of high-altitude research and rocket tests as they relate to the satellite program. Included is a discussion of the future prospects of space travel.

Rockets, Missiles and Space Travel, Willey Ley, (Viking Press, $6.75). Revised edition of the history of rocket and missile research. Ley also discusses the future prospects of man and his search to conquer space.

Rockets Through Space, Lester Del Ray, (John C. Winston, $3.95). An informative, excellently illustrated account of research and development in rockets and missiles and a glimpse into the future of flight into outer space.

Retirement From the Armed Forces (Military Services, $4.95). A complete, up-to-date compilation on all aspects of retirement. The book was prepared by a committee of retired Air Force, Army, and Navy officers.

Week-end Pilot, Frank K. Smith (Random House, $3.75). Humorous, informative account of a big city lawyer, his experiences in learning to fly light aircraft, and the fascinating hobby flying has become for him.

The One That Got Away, Kendal Burt and James Leasor, (Random House, $3.95). The amazing story of Luftwaffe ace, Franz von Werra, and his three escapes from British POW camps—the last in Canada from which he made his way back to Germany.

DEW Line: Distant Early Warning, The Miracle of America's First Line of Defense, Richard Morenus (Rand McNally, $3.95).

Lifeline in the Sky, Clayton Knight, (William Morrow, $6.00).

The History of the United States Air Force, 1907-1957, edited by Dr. Alfred Goldberg, (D. Van Nostrand, $6.75).

MEET MACH

The Forgotten Man Who First Plumbed Supersonic Secrets

In the roaring onsurge of supersonic flight, today's magic byword is Mach—the index for measuring an air vehicle's velocity in terms of the speed of sound.

Contrary to widespread belief, the term is not something brand-new, invented especially for the latest explosive chapter of the Air Age. The word comes from the name of Dr. Ernst Mach, brilliant Austrian scientist, whose basic research in sonics and ballistic phenomena established the key principles which guide modern aerodynamics, tackling problems linked to the assault on space.

Surprisingly enough, this lengthy research program was initiated in the early 1870s when the Wright Brothers were mere children, and it was completed in the decade before they made the first powered aircraft flight at Kitty Hawk, N. C., in 1903.

Mach's greatness rests not solely on his work in this field. As a physicist, he did much toward establishing a basis for scientific thinking which led to the acceptance of relativity and its associated theories. Among those profoundly influenced by his ideas was Dr. Albert Einstein, who later formulated the revolutionary Theory of Relativity, destined to find application in the great breakthrough achieved in unlocking atomic energy.

Mach also fathered a school of philosophy whose methods and tenets outraged a then-obscure political refugee living in Switzerland, one Nikolai Lenin, future architect of the Soviet Union. In 1908 this original Bolshevik violently assailed Mach and his philosophy in a lengthy book branding the scientist as hostile to his own Marxist dogma. So deep was Lenin's animosity that, despite his death many years before Mach terms came into practical use, the Red Air Force shied away from expressions with the name of the anti-Marxist genius.

Ernst Mach was born February 18, 1838, at Turas, a small town in the old Austrian Province of Moravia. His formal education carried him through the University of Vienna, among the Continent's best, where he received his doctor's degree in physics in 1860.

PHOTO FROM LIBRARY OF CONGRESS

Dr. Ernst Mach (1838-1916)

His teaching career began as professor of mathematics at the University of Graz in 1864. Three years later he moved to the University of Prague, heading its physics department until 1895. He left to join the faculty of his alma mater in Vienna, where he completed his research in sonics and published the results. Soon afterward he was felled by a stroke in 1898 and left paralyzed. He retired from the university in 1901, and on the eve of World War I moved to a retreat near Munich, Germany, where he died February 9, 1916.

The research work that was to put Mach's name in aeronauts' vocabulary started at Prague. At the outset he concentrated on optics and acoustics, publishing his first papers in 1873. By the 1880s he was studying shock waves, turbulence, and other effects generated by the violent passage of ballistic objects through the atmosphere. Although photographic equipment and techniques were primitive, this pioneer successfully trapped on camera plates, as early as 1881, pictures of ballistic flight phenomena. In 1889 his camera caught what is believed the first photograph of a supersonic air jet stream issuing from a vent.

Besides the Mach number for speed, there are several other terms using the name of the supersonics world pioneer. Among them are: mach angle, mach effect, mach front, mach line, mach stem, and mach wave.

These now familiar expressions in flight study were slow coming into use. Mach number first appeared as a technical term in a 1929 German text. It was not until 1937 that this and other mach words got established in English. The opening years of WW II accelerated wide international adoption.

A conspicuous exception was the USSR. Although the Communists perforce availed themselves of the Austrian physicist's formulas, they chose to speak of sonic speed in terms of the "Bairstow Number," obviously named for Sir Leonard Bairstow, the noted British aerodynamics authority who has worked on the elaboration of Mach's principles. On one occasion Moscow took pains to explain obliquely this did not mean the USSR was denying Mach's genius. Lenin, so the explanation ran, recognized the man's stature as a scientist, but had attacked him and his followers solely on philosophic grounds.

Since 1950, however, there evidently has been a switch in Kremlin thinking on sonic nomenclature: in recent years the Red Air Force has changed to using the name of the Lenin-detested "heretic" philosopher like the rest of the world. Whether this will be permanent remains to be seen.—*W. A. Kinney*

TRAINING THE PILOTS OF TOMORROW

THE SKY IS NO LIMIT FOR THE MEN WHO CAN QUALIFY FOR AN AIR FORCE STEADILY OUTMATCHING THE SPEED OF SOUND

At first it's perplexing, but the cockpit of the T-33 soon becomes familiar.

by John L. Scherer

Threshold to the Mach Age. That's Lackland AFB for the bulk of aspiring future Air Force pilots today, although the idea may not occur to those reporting at this Texas center for training which carries the deceptively unexciting and earthbound label—Preflight.

New arrivals soon find the deceptive label is their introduction to a rigorously intensive and exacting program which the Air Force has mapped to develop the pilots—and leaders—of tomorrow, with all the stamina, resourcefulness, and versatility demanded by the incredible new era of flight now so swiftly evolving.

Those who make the grade are the coming elite who will be masters of unbelievably complex and costly air vehicles, which hurtle through the heavens at velocities far surpassing that of sound and at altitudes high in the upper stratosphere, even space.

Even the finest equipment now operational affords scarcely a preview of the types tomorrow's pilots may expect to fly. Current targets are manned aircraft, with speeds surpassing Mach 3, ceilings of upwards from 15 miles, and unprecedented ranges. These will be teamed with super-range missiles in the Mach 20-plus class. And the best inventive genius is already at work to create even more improved air instruments to outdo these programmed performances.

The whole scope and spirit of the Pilot Training Program, the way it is constantly adjusted to cover rapidly changing developments, offers proof of the Air Force's thinking on the preeminent importance of the role man will continue to fill in the skies during years to come. Despite all the amazing accomplishments that modern science and technology have produced or promise, they have created nothing remotely approaching that most versatile of all precision instruments, the well-trained human mind.

By the time student pilots earn their silver wings, they will represent a dollar training investment by Uncle Sam which runs into six figures. So it is an expensive opera-

tion which has to yield gilt-edge returns in terms of fliers who are to be the guardians of future peace or stern avengers, if it be broken.

In all, the program requires about 15 months, including the equivalent of three months in Preflight. If the time involved seems relatively short, the pace is driving, for it must be gaited to the ever-faster tempo at which the Air Age advances.

The pace takes its toll. Out of every 10 starters, an average of slightly better than six win through to their coveted goal by demonstrating conclusively they have what it takes.

The First Step

The challenge for a majority of would-be pilots begins at Lackland, near San Antonio where stands the Alamo, famed monument to American courage and stubborn devotion to freedom in the face of grim odds. Immediately upon reporting, newcomers are plunged into a training cycle with a twofold purpose.

One is to fortify and stimulate a man's known ambition to fly. The other is to condition him mentally, physically, and psychologically for the grind ahead—strenuous, but not without the rewarding feeling that achievement brings. After Preflight comes a half year at Primary Flying School, then another crucial six months in Basic Pilot Training.

Who are the new trainees? One group will be Aviation Cadets—young men with or without prior military service, or airmen and NCOs straight from active duty. The other consists of officer students, mainly recently commissioned AFROTC graduates, plus some officers from the Air National Guard. Since graduates of the service academies and active-duty Air Force officers are already thoroughly grounded in Preflight fundamentals, they bypass Lackland and proceed to a Primary School without delay.

The cadet course runs a jam-packed dozen weeks for a total of 528 hours. Because trainees, for the most part, have scant, if any, familiarity with officer-grade military training or a broad background in aeronautics, they tackle a curriculum which sounds at first as if it included about everything in the book.

And this is Project Z.

The range runs from aviation science, air intelligence, and aviation physiology to small-arms training, introduction to the use of the parachute, the business of pay and allowances, the Aviation Cadet Honor Code and the customs, courtesies, and traditions of the service. Naturally, a generous measure of physical training, formation drill, ceremonies, and inspections goes with the skull work.

The individual student is under continuous scrutiny not only by his instructors but also his fellow trainees, with the common purpose of arriving at an exact evaluation of his particularly valuable abilities and also for searching out shortcomings for corrective treatment. This process is a prime essential in the development of leadership talent. It teaches a man to know himself—the beginning of all wisdom—and see the need for self-criticism, which in turn shows the necessity for automatic self-discipline. A man who cannot impose discipline upon himself lacks the command character to enforce discipline on others, much less inspire the confidence a real leader evokes.

Plus X, Y, Z, Too

This rundown hits only a key sample of a cadet's Preflight activities, but any such sketch should not omit some reference to the three projects identified as X, Y, and Z.

Project X involves a series of tests designed to determine an individual's potentiality as a leader, along with his ingenuity and tenacity in sticking with a problem until it is licked.

Project Y, of which more details anon, is a physical-confidence course, described by Lackland's Director of Operations, Col. J. P. Jones, as "valuable in assessing a man's reliance

and resources, spiritual and physical, when confronted with situations of stress. It also enables an instructor to detect any signs of mental misgivings in an individual or false fears that he might not be bodily equal to cope with the demands of an emergency."

Colonel Jones further pointed out that exposure to manufactured danger, so to speak, likewise contributed toward strengthening a man's sense of faith in what he has the physical capacity to do or take, as well as toward toughening his moral fibre. "It is this reserve of inner strength," he observed, "that is so often the decisive factor in the naked face of great danger or under other abnormal conditions conducive to fear and other confusing emotions."

Project Z means the parachute tower drills in which trainees learn the technique of hitting the silk and landing properly with a 'chute—experience calculated to eliminate any element of panic in those forced to bail out during some real future emergency.

To get back to Project Y, like those multibarreled questions on TV programs, it comes in 12 installments. The initial ones make little demands on courage or skill, but progressively they get tougher. The climax is literally a trial by fire.

The trainee's mission is to rescue a "pilot," represented by a sandbag, trapped inside the flame-wrapped cockpit of a plane that has hypothetically just crashed.

Reaching the cockpit, however, involves first the equivalent of a dash through the corridor in a burning house. This "fire lane" is a series of metal door frames fitted with jets which spurt out flaming gas. After the student has run this gantlet, he must face more spurting fire from valves set in the wing and around the cockpit of the "crashed" aircraft.

Of course, alert instructors are stationed at controls to cut off the gas from the jets should a trainee happen to trip or succumb to fright. But that rarely happens, and most men emerge from the ordeal surprised and impressed by their own courage.

How helpful are these tests? Lackland's Commander, Maj. Gen. H. L. Grills, comments: "It is important that trainees overcome their fear of natural forces or unpredictable situations. It may mean the difference between surviving unharmed or risking grave injuries, if not worse."

Course Two

Lackland's second course — that for AFROTC graduates and officer reservists—has a six-week schedule, only half as long as the cadet's course, but the days are just as crowded.

Obviously, the explanation for the shorter time period is the fact that these students have all had the benefit of previous instruction about the rudiments of military life, a knowledge of command responsibilities, and an opportunity to absorb the distinctive Air Force spirit.

All officers collect their regular pay and allowances while in training. The pay of cadets is $111.15 monthly. Those with the rank of staff sergeant or higher, continue to draw their previous pay and allowances, and are called aviation students instead of cadets. Both cadets and students draw an extra $50 per month flight pay when they begin flying.

Regardless of which of the two classes a trainee chances to be in, he can be certain his instructors are the best qualified obtainable by the Air Force. They are men of maturity and discernment, with top practical experience and thorough, up-to-the-minute knowledge of both equipment used and the subjects they teach, whether academic or technical.

As might be expected, the emphasis on trainee discipline is stern and unrelenting, particularly where little things are concerned. "Minor pressures are kept up to see if the student can take it," Colonel Jones explains. "If he is dedicated in his desire to earn his wings, he'll stick it out. After all, we are all subject to numerous petty annoyances in any walk of life, but we carry on."

This "minor pressure" treatment serves an even more important end. It inculcates a habit of paying automatic attention to seemingly minor matters. This habit—a "must" in the makeup of a flying officer—carries over to the student's flight training where constant attention to all details is indispensable.

The rugged character of Preflight takes a toll of about 15 percent of those in the three-month classes. These eliminations are due mainly to academic or military deficiencies, with a few washouts for physical reasons. The attrition rate for officer students averages seven percent, mostly for physical defects which where not readily detected in medical examinations preliminary to reporting.

For all the sweat they have experienced, successful trainees enthusiastically agree that Lackland does its job well. They depart with the soaring confidence expressed in the words: "I'll make it!"

Primary Phase

Primary flight training may take a student to any one of seven air bases—Bainbridge or Spence, both in Georgia; Bartow or Graham, in Florida; Hondo or Moore, in Texas; or Malden, in Missouri.

Now the fledgling pilots get their first actual contact with military flying, and how eagerly they swarm over the trim Beech T-34A and the North American T-28 — training planes in which they will start learning to apply the principles they studied in the theory of flight.

In the primary schools all instruction related to flight is conducted by employees of civilian firms who operate the Air Force schools under contract. The instructors, both in classroom work and in flying, are highly skilled specialists of proven experience.

The program, however, is carefully monitored by Air Force personnel to make sure that all standards set are scrupulously met by the responsible command, the Flying Training Air Force. Air Force pilots regularly evaluate a student's progress; FlyTAF boards make periodic checks on the efficiency of the civilian instructors; and Air Force maintenance teams inspect the mechanical upkeep of the trainers, which are USAF property placed at the disposal of the contract-operator.

In matters of strictly military routine, the trainee's life is supervised by air officers on the staff of the Pilot Training Group Commander assigned to the base. Never are trainees allowed to forget for a minute

they are to be future officers of the USAF, as well as pilots. This part of the schedule continues the heavy emphasis on development of character and leadership qualities, the enhancing of professional skills and techniques, plus the usual round of drills and ceremonies, and the inevitable physical training. "A sound mind in a sound body," is definitely more than an old adage throughout pilot training.

The Feel of Wings

Any monotony close-order drill may engender is quickly dispelled by the thrill and adventure which are bound up in a trainee's introduction to flight. He gets 130 hours aloft, and those hours bring the vision of wings nearer.

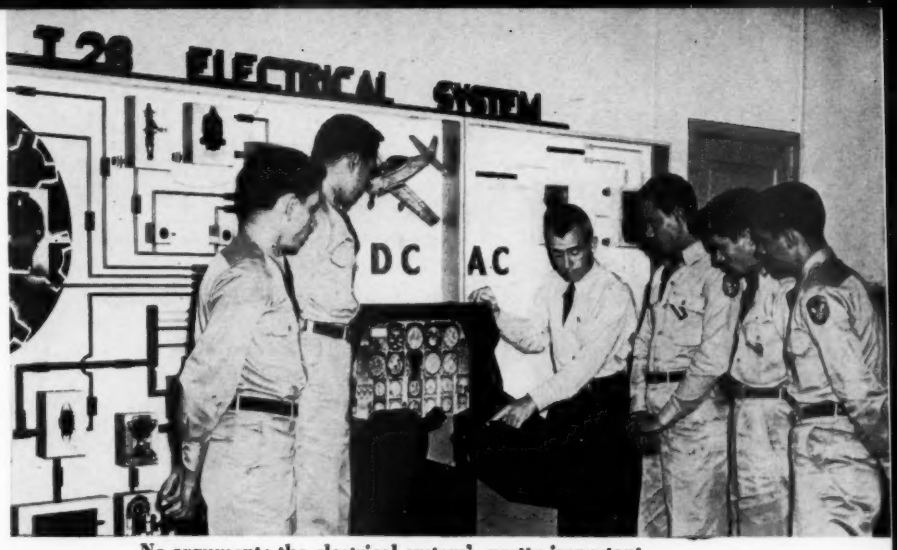
The first flights are in a T-34, powered by a 225 h.p. engine, and the instructor utilizes them to appraise a trainee's flying aptitudes, as well as to show him how to handle the controls and other rudimentary techniques.

After from 10 to 15 hours of airborne instruction, the student comes to that "day of days" in the life of a man aspiring to become an Air Force pilot. He takes the T-34 up alone.

Once a triumphant fledgling successfully lands after his first solo, he can count on being pulled bodily from the cockpit by his elated classmates, borne on their shoulders to the base swimming pool, and there to be dumped unceremoniously into the water.

Following solo, the trainee takes the T-34 gradually through a course which includes basic instrument flying, repeated touch-and-go landings and takeoffs, aerobatics, and cross-country and night flights. The instructor he left on the ground when he soloed is back with him, however, guiding and supervising him constantly.

In all, a student spends 30 hours in the T-34 before he is considered ready to graduate to the more powerful T-28, with its 800 h.p. engine. He has 100 hours in this aircraft to develop his proficiency as a pilot, making a number of check flights under the critical eyes of both civilian and military pilots before finally winning their coveted nod of approval.



No argument; the electrical system's pretty important . . .

Supplementing the 130 hours a student gets in the air are 226 hours of classroom study on such subjects as flight theory, aircraft engineering, radio communications, navigation, flight instruments, weather, aural and visual codes, flight problems, and physiological exercises. Stiff examinations determine how well he has progressed in these studies.

In the classroom, too, he plans realistic cross-country flights subsequently made in the T-28. He also learns how to file flight clearances, evaluate weather reports, and gets practice for many inflight operations through the use of ground-training aids. Use of the Link trainer enables him to keep improving his ability in instrument flying.

At the end of Primary's six months, the ranks of a given class will be 20 percent thinner. The washouts are due to various causes, among them flying, academic, military, or medical deficiencies; fear of flying; and self-initiated elimination.

Now Basic

The next and final hurdle is six more months' assiduous work in Basic Pilot Training. Here the trainee finds himself exclusively in the hands of Air Force personnel, unlike Primary where he was dealing part of the time with civilian instructors. He has now reached the stage where he is to learn how to handle faster, more advanced aircraft and also the professional skill of using his plane as a combat weapon. Teaching in these specialties is strictly an Air Force job.

Entering on this phase of the program, the trainee soon discovers that the base to which he is assigned is quite similar to those of operational units. His contacts with support and administrative personnel broaden. He begins to realize that, as an officer, he must expect to discharge important ground duties in addition to his flying. The importance of teamwork both on the ground and in the air is brought home to him forcefully.

His instructors are top-flight men. Many are combat veterans of Korea. Some may be fairly recent Basic graduates who possess that unusual combination, both the aptitude for teaching others how to fly and the inspiring genius for doing it successfully. Such men are given Basic assignments after a special instruction course at Craig AFB, Ala. They are in the best educational tradition that good teachers who delight to teach make the best teachers.

Whether a student gets orders to a single-engine jet school or a multi-engined prop one is decided by several factors. Consideration is given, of course, to his personal preferences, but the recommendations of his previous instructors and flying supervisor, as well as the immediate needs of the Air Force figure in the decision. And the decision will largely determine his ultimate type of flying duty — fighters, interceptors, bombers, transports, etc.

Students, tapped for single-engine jets, are assigned to Bryan, Laredo, or Webb, all bases in Texas. The

multi-engine men go either to Goodfellow or Reese AFB, both in Texas, or to Vance AFB in Oklahoma.

Trainees in the first-named group make their acquaintance with jet flight in the two-place Lockheed T-33 *Shooting Star*, which operates at speeds from 300 to 500 m.p.h. at altitudes of 40,000 feet. Those in the multi-engine class break in with the North American TB-25 *Mitchell*, the redoubtable medium bomber of World War II fame, but a jet multi-engined trainer is planned for supplanting the TB-25 in the future.

Single-engine students have 115 hours in the T-33, or one hour less than the multi-engine men log in the TB-25. In both cases it's the same story of practice, practice, practice; check flight after check flight, until flying becomes more and more second nature, and each hour brings wings that much closer.

And Still Book Learning

Basic brings no escape from books and classroom work. Some courses are advanced continuations of subjects familiar in Primary—the weather, navigation, instruments, and so forth. Others are new—survival indoctrination, special weapons, and aircraft recognition.

In the broader military field the concentration is on problems, customs, ceremonies, functions, and operations which men will meet on active duty at regular Air Force bases.

The attrition rate in Basic is 10 percent, with slightly more than half the washouts due to flying deficiencies. The balance is distributed among the same causes responsible for trainee failures in Primary.

But for the men who have what it took the successful completion of Basic brings the proud award of their silver wings, the glorious emblem of great ambition achieved with tireless effort, courage, and skill.

Those who were aviation cadets or students also get their gold bars as second lieutenants, and that insignia symbolizes something very tangible —a pay boost from a cadet's $161.15 monthly to the $438.58 drawn by an unmarried pilot, living off-base, and on flight duty. If the new 2d lieutenant marries, the figure is $455.68.

As bona fide Air Force pilots now, the Basic graduates are ready for Advanced Pilot Training. Some 53 percent proceed directly to USAF operational units such as SAC, TAC, MATS, etc.

Others go for this phase to one of seven AF Bases—Luke or Williams in Arizona, Perrin or Randolph in Texas, Nellis in Nevada, McConnell in Kansas, or Georgia's Moody.

The new pilots are introduced progressively to the latest operational aircraft, and learn how to exploit them with maximum efficiency for their assigned military missions.

For the single-engine pilot there lies ahead the thrill of piloting such planes as the Republic F-84 *Thunderjet*, North American F-86 *Sabre*, the Lockheed F-94 *Starfire*, and finally those masters of Mach—the supersonic fighters and interceptors of the already celebrated century series—the *Super Sabre*, *Voodoo*, *Starfighter*, *Delta Dagger*, and *Delta Dart*.

The multi-engine graduate may look forward eventually to taking the controls of the Boeing B-47 *Stratojet*, the Boeing B-52 *Stratofortress*, or the Boeing KC-135 *Stratotanker*.

And in all categories there are even more advanced air vehicles on the drawing boards or in various stages of design and planning.

At advanced training bases, the young flying officer experiences conditions simulating actual combat—bombs and rockets bursting on desert target ranges, high-altitude strategic bombing, and radar-guided interceptions. Gunnery practice is conducted with ever-increasing accuracy.

Advanced training includes 116-117 hours flying during 40 to 90 training days, depending on the type of training and aircraft involved. Graduates are assigned to duty with USAF operational units.

Flying Training Air Force, commanded by Maj. Gen. H. R. Spicer, is part of the Air Training Command, headed by Lt. Gen. Charles T. Myers. The training program is under constant study and research and is, of course, subject to inevitable change. For example, in Project Palm, FlyTAF is testing the possibilities of training Primary students in a jet training plane instead of waiting until Basic to make the transition from piston-engined trainers to jets.

Project Palm, using Cessna T-37 twin-engined jet trainers, capable of a speed of 400 m.p.h., is now under way at Bainbridge AB, Ga. If successful, the T-37 will likely supplant the T-28 in the Primary course in the near future.

The Five-Year Program

Recently the Air Force announced that future pilots must serve five-year tours of duty instead of the three years previously required. Through this plan the Air Force believes it will get a better combat-ready pilot for the $150,000 spent on his training and the two-and-one-half years it takes to train him. Further, the pilot who spends five years in the Air Force is certain to be better motivated and more likely to make the service a career.

Commenting on the new five-year plan, General Spicer said, "I think it is one of the most sensible steps the Air Force has ever made. The new policy is certain to produce a greater return for the Air Force's investment. We'll get a better trained, better motivated officer-pilot."

Training policies and programs change and will continue to do so, for only by facing new conditions with new methods can the Air Force carry out its pledge of "more Air Force for the taxpayers' dollars."

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TEAM EFFORT

At press time, a message was being readied at Hqs USAF decreeing five-year tours for navigator trainees. The proposed plan would be tailored along the same lines as the pilot tour outlined above.

Presently undergoing final analysis and staff coordination, the proposal is expected to be ready for implementation in the near future.

Lt. Col. W. O. Brimberry, Chief, Navigator Training Section, explained that current inconsistency in tour lengths of crew members was unrealistic. "For example," he pointed out, "SAC crews are only as good as their team effort. When one member of that crew is serving a shorter tour than another and chooses to leave at the end of his obligation, it means an entire new team must be trained."

ASTRONAUTIC SYSTEMS

The Astronautics Systems chart reproduced on the back cover and explained below illustrates the Convair Astronautics Division's present ideas about one probable step-by-step evolution of the vehicles and propulsion systems needed to transport man eventually outward from this planet. Also indicated are Convair's estimates of the velocities which must be attained and the distances to be traveled for man to reach various goals in space.

It . . . now seems practical to attempt a definition of objectives in the achievement of manned space flight. Logically, this achievement is likely to follow an orderly development along four main lines—and possibly a fifth—each assigned to a broad band of space exploration. These probable developmental steps are:

1. Exploration of the outer fringe of the terrestrial atmosphere by means of manned orbital vehicles. These vehicles would be capable of making several revolutions around the earth before drag forces a landing. Major objectives of this preliminary state of space flight development would be twofold: Adaptation of men and machines to the conditions of high ascending accelerations necessary to attain operating altitude, and assembling more data about man's existence in the environment in space.

2. At considerable altitudes above the earth's atmosphere, satellites—permanent manned space stations—will serve first as space laboratories, later as launching bases for further exploration of space by other vehicles.

3. Operations in Earth-Moon space for exploration of our nearest celestial neighbor. Here such explorations would enable us to get the feel of space.

4. Interplanetary flight.

5. In the far distant future, perhaps interstellar and intergalactic flight.

Each of these objectives is charted here with respect to earth in terms of distances and amounts of energy required.

On this chart distances to targets are expressed logarithmically in nautical miles on the vertical scales at the extreme left and right of the chart. Close to a planet's surface, distance is termed altitude. Distances between planets are expressed according to flight path (orbit to orbit) rather than between planetary surfaces or centers.

The horizontal scale at the bottom of the chart defines the energies required for the respective missions, expressed in terms of velocities that must be imparted to a vehicle, in thousands of feet per second.

On the right side of the chart, distances are bracketed by the propulsion systems that, on the basis of present technology, appear likely to be practical for these various regions of space. Symbolically, these propulsion systems are pictured in the adjacent column. The vehicles are not drawn to relative scale.

Regions of space, indicated on the left side of the chart, are defined according to predominating physical characteristics. Their arbitrary limits are understood to reflect not sharp changes but a gradual merging of one region into the next. It should be noted that because the planets are placed logarithmically on the grid, Uranus and Neptune have been omitted from the chart, as they would lie close between Saturn and Pluto.

Beyond earth's atmosphere is *terrestrial* space, ranging roughly to one earth radius altitude (3,444 nautical miles), where terrestrial magnetic and electric influences are still comparatively strong.

In *cislunar* (this side of the Moon) space, the Earth's gravitational influence decreases, while simultaneously the Moon's influence increases, until, in *lunar* space, orbits are dominated by the Moon's gravity field.

In *translunar* space (beyond the Moon), the combined gravitational attraction of Earth and Moon is still the predominating influence on a space vehicle. But at about 500,000 nautical miles distance, the Sun becomes the dominating center of attraction and therewith we enter the vast realm of *interplanetary* space, in which are imbedded the various planetary spaces. Within the Sun's gravitational field, each of the target planets creates a local gravitational pocket (as does Earth) that overrides the Sun's influence as we approach that planet. In interplanetary space, each planet thus becomes a perturbative force as a space vehicle nears it.

Far beyond the planet Pluto, the solar g-field becomes insignificant and *interstellar* space begins. Finally, beyond our galaxy stretches the starless void of the *intergalactic* region.

The velocities expressed on the horizontal scale are those that the vehicle must be capable of attaining to reach any specified objective. These are expressed as ideal velocities. Ideal velocity is a mathematical expression of the total energy in the propulsion system of the vehicle. If all the energy were used to propel the vehicle, the vehicle could attain ideal velocity in flight. However, part of the total energy is used to overcome gravity and atmospheric drag (if any). Thus the vehicle attains an actual velocity somewhat less than ideal velocity. The velocities on the abscissa (bottom scale) are the sum total of the minimum ideal velocities required for all maneuvers during a round trip from the earth to the target planet and back.

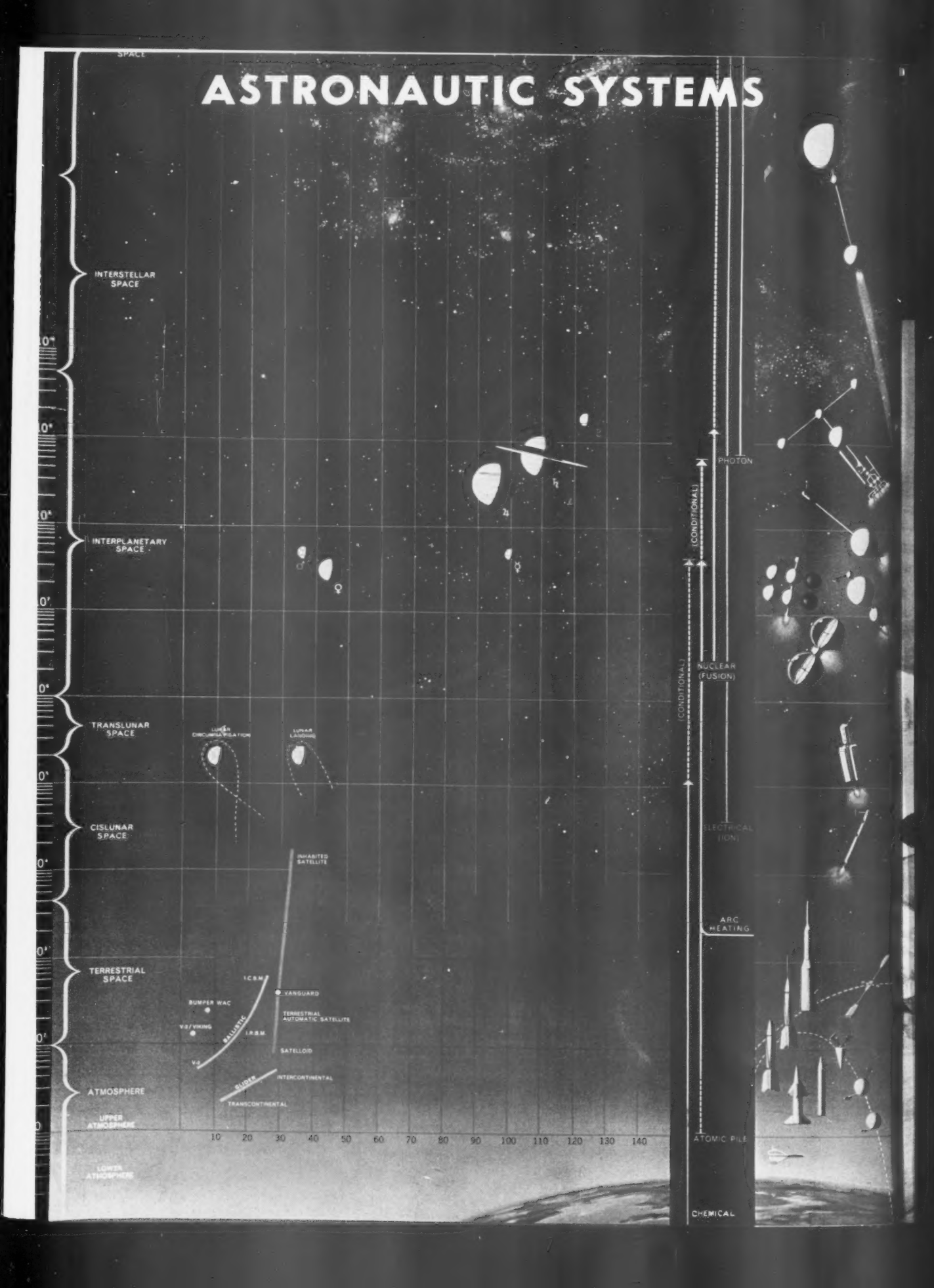
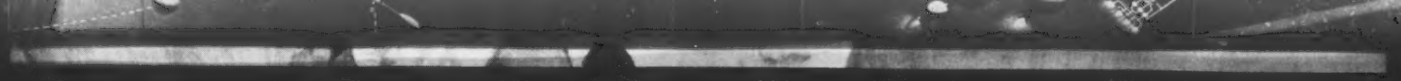
The grid on the chart correlates the distances of the astronautic objectives with the ideal velocities required to reach these objectives. The energies required to reach the five main objectives are computed in these ways:

For manned orbital gliders, the ideal velocity is the energy required to attain altitude and make the desired number of revolutions before the vehicle falls back to earth. For permanent satellites, the ideal velocity is that required to reach and remain in the satellite orbit. Once orbital velocity is attained, propulsive force is no longer needed since there is no atmospheric drag at this altitude.

The ideal velocity for rocket gliders, ballistic missiles, satelloid and high-altitude rockets is determined on the basis of cut-off velocity requirements.

In the remainder of the astronautic objectives, ideal velocity is computed as that required to go from an orbit 300 nautical miles above earth to a satellite orbit around the target planet. The energy levels given, then, are close to minimum.

In the propulsion range column at the right, the solid arrows indicate distances for which the various propulsion systems are applicable. The broken arrows show that a particular propulsion system could be extended to these respective distances theoretically, but this probably would not be practical. The propulsion systems are displayed according to energy sources—i.e., chemical combustion; atomic pile; electric-arc heating (but not burning) of gases; electrical acceleration of ions (charged molecular particles); nuclear fusion; and finally, conversion of matter into light (photonic system).


ASTRONAUTIC SYSTEMS
SPACE
INTERSTELLAR SPACE
INTERPLANETARY SPACE
TRANSLUNAR SPACE
CISLUNAR SPACE
TERRESTRIAL SPACE
ATMOSPHERE
UPPER ATMOSPHERE
LOWER ATMOSPHERE
LUNAR CIRCUMNAVIGATION
LUNAR LANDING
INHABITED SATELLITE
I.C.B.M.
VANGUARD
BUMPER WAC
TERRESTRIAL AUTOMATIC SATELLITE
V-2/VIKING
BALLISTIC
I.R.B.M.
SATELLOID
V-2
BOOST
INTERCONTINENTAL
TRANSCONTINENTAL
10 20 30 40 50 60 70 80 90 100 110 120 130 140
PHOTON
(CONDITIONAL)
NUCLEAR (FUSION)
(CONDITIONAL)
ELECTRICAL (ION)
ARC HEATING
ATOMIC PILE
CHEMICAL